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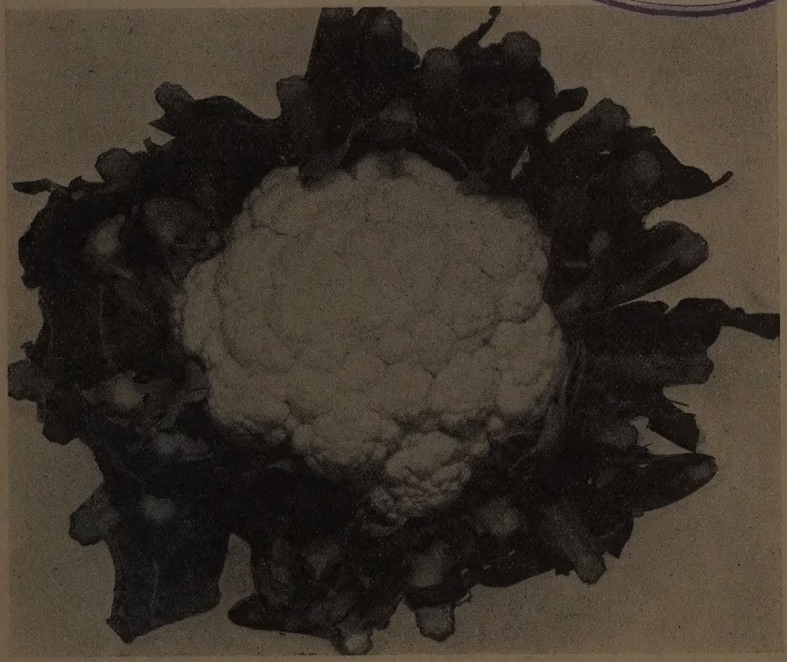
The Control of Diseases and Insects Affecting Vegetable Crops on Long Island

C. R. Crosby and Charles Chupp



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DISEASES AND INSECTS AFFECTING VEGETABLE CROPS ON LONG ISLAND

C. R. Crosby and Charles Chupp

In this bulletin an attempt has been made to bring together all the more pertinent facts concerning the practical control of the insects and diseases that affect the important vegetable crops on Long Island. Much of this material has been published in bulletins or elsewhere but is available only to those who have access to a large agricultural library. Considerable additional information has been obtained from unpublished data of the research workers of the state experiment stations.

Doctors Hugh Glasgow, James G. Horsfall, H. C. Huckett, and H. S. Cunningham, of the New York State Agricultural Experiment Station at Geneva, New York, have been especially helpful in furnishing information and in making suggestions as to the best methods of control. Many valuable suggestions have been received also from the county agricultural agents in Nassau and Suffolk Counties. It is hoped that this summary will be of use to the growers of Long Island in their efforts to produce paying crops of vegetables.

CABBAGE, CAULIFLOWER, AND RELATED CROPS

The most serious insects and diseases with which the cabbage grower has to contend in growing the crops are root-maggots, blight, black-leg, aphids, and worms. Seed treatments are required for the control of blight and black-leg. To effectively prevent loss in the seedbed, mercury treatments are required for maggot, wire-stem, and club-root control. Summer treatments are confined largely to dusting or spraying for aphids and worms.

CABBAGE ROOT-MAGGOT

(*Hylemyia brassicae* Bouché)

The cabbage root-maggot is a serious pest in seedbeds of late cabbage and cauliflower. It attacks also early crops of these vegetables in the field, as well as brussels sprouts, broccoli, and turnips. Radishes are especially subject to infestation. Fortunately late crops of cabbage and cauliflower usually escape serious injury in the field.

The adult of the cabbage root-maggot is a fly resembling the house fly in general appearance. It is about the same size but seems narrower, owing to the way the wings are held when at rest. The flies appear about the time sweet cherries come into bloom, and reach their maximum abundance when plums of the Gage type blossom. These flies may be observed on

sunny days resting in sheltered spots on the seedling plants. When disturbed, they take wing quickly and, after a short rapid flight, usually come to rest on another plant a few feet away. The female fly is provided with a long extensile ovipositor with which she places her eggs in cracks in the soil close around the base of the plants. The eggs are white, elongate, and can be easily seen with the unaided eye. They are most readily found by removing the soil around the stem of the plant with a knife point. Most of the eggs will be found within ¼ inch of the surface.

The eggs hatch in from three to eight days, and the minute, whitish maggots work their way down along the stem and the root, feeding at first only on the surface. They rasp the surface tissue with their hook-like mouth parts; and, as the maggots increase in size, they channel out deep grooves or burrow into the larger roots or the base of the stem. Infested seedlings take on a lighter color than normal and acquire a bluish cast. They wilt more quickly in the heat of the day. Later they turn a yellowish color, wither, and die.

The maggot becomes full-grown in about three weeks, and then transforms into a brownish puparium, usually in the soil close to the injured plant. A second brood of flies appears in from twelve to eighteen days, and one or two additional broods may develop later in the season. Most of the injury to cabbage and cauliflower, however, is caused by the first, or spring, brood of maggots. Radishes and turnips, however, may be seriously injured later in the season.

Control in seedbeds

Corrosive sublimate has been generally used for the control of root-maggots in the seedbed, but calomel has decided advantages under certain conditions, and its use has increased during the past few years.

Both corrosive sublimate and calomel are mercury compounds. Corrosive sublimate is also known as *mercuric chloride*, and calomel as *mercurous chloride*. Because of the similarity of the chemical terms, confusion is likely to arise, and it is better to use the common names for these substances. The finely ground commercial corrosive sublimate commonly found on the market is satisfactory for maggot treatment. Calomel does not dissolve in water but is applied in the form of a suspension. It is therefore essential to use a very finely divided product, like flour.

Corrosive-sublimate treatment in cabbage seedbeds

For protecting seedling cabbage plants from root-maggot attack, corrosive sublimate is used at the rate of 1 ounce of the finely divided powder in 10 gallons of water. The powder is dissolved in a small quantity of hot

water and then diluted to the required amount. The solution should not be stored in a metal container because of its corrosive action.

Corrosive sublimate is effective only against the eggs and the newly hatched maggots. In early plantings the first application should be made when European plums of the Green Gage type are in bloom. In later plantings, where the flies have already appeared and are laying eggs, the first application should be delayed until from three to five days after the plants have come up, to avoid injuring them. Two or three applications at weekly intervals may be found advisable, depending on the abundance of the flies.

The corrosive-sublimate solution may be applied to the plants by means of a watering pot from which the perforated sprinkler has been removed and the spout plugged with a notched cork to restrict the flow, or by some better device, such as a small tank mounted on a wheelbarrow. The solution is poured along the row so as to moisten the soil around the base of the plants. One gallon of the solution will treat 40 feet of row for the first application; in later applications more will be required. If a heavy rain follows immediately after an application of corrosive sublimate, it may be advisable to make the next treatment a little sooner than would be required by the regular schedule. It is well to wait two or three days, however, before repeating the application.

Corrosive sublimate treatment in cauliflower seedbeds

Cauliflower seedlings are more subject to injury from corrosive sublimate than are cabbage seedlings, and it is therefore advisable to use it at a greater dilution—1 ounce in 15 gallons of water for the first application, and 1 ounce to 10 or 12 gallons for the others.

Calomel treatment of seedbeds

For the treatment of the tender seedlings of cauliflower and brussels sprouts, an aqueous suspension of calomel may well be substituted for the corrosive-sublimate solution. This applies also to the treatment of cabbage seedlings that have been attacked by flea beetles, where the use of corrosive sublimate is likely to augment the injury. The use of calomel under such circumstances will avoid injury to the plants and will give excellent control of the maggot if properly applied.

Calomel may be used according to the general directions given for corrosive sublimate except that the calomel, being insoluble, must be constantly agitated while the suspension is being applied. Also, in some cases it may be advisable to increase the dosage of calomel to 2 or 4 ounces to 10 gallons of water. A single application of calomel at this strength will often

give the same degree of control as that usually obtained from the three generally recommended applications of corrosive sublimate. Were it not for the difficulty of keeping the calomel in suspension while making the treatments, its use would be much more general than it is at present.

Calomel treatment of cabbage and cauliflower seed

Recent experiments indicate that by treating cabbage and cauliflower seed with dry calomel powder, maggot injury to the seedlings can be greatly reduced. The seed is moistened and worked up with the calomel. About 1½ pounds of the powder will adhere to 1 pound of the seed.

Control on early cabbage, cauliflower, and broccoli in the field

When cabbage or cauliflower seedlings are transplanted into the field during the egg-laying period of the flies, the plants are likely to become heavily infested by maggots and seriously injured or killed. The most practical way to prevent this loss is to use corrosive-sublimate as described for the treatment of seedbeds. Two or three applications at weekly intervals may be found necessary, depending on the abundance of the flies and the time at which the seedlings are set out in the field. The first applications should be made within three or four days after the seedlings are transplanted. About 2 or 3 ounces of the corrosive-sublimate solution is poured around each plant at each treatment. The solution may be applied with a pail and dipper, with a watering pot from which the sprinkler cap has been removed, or with some mechanical applicator.

Another method of control consists in applying calomel to the plants in the field. One pound of calomel is mixed with 5 pounds of ground limestone. This mixture is applied with a hand duster, giving a puff of the dust at the base of each plant and taking care to drive the dust into the crevice between the base of the stem and the surrounding soil. A bellows type of duster should be used. About 18 pounds of the mixture is needed for each acre.

Still another method of protecting the plants from maggot attack has been developed in Nassau County. It has given satisfactory results under commercial conditions. It consists in dusting only the stems of the seedlings after the plants have been pulled, but before they are set in the field, with a mixture of 1 pound of calomel and 6 ounces of cornstarch. The mixture is applied with a large salt shaker. If the dust does not flow freely, the holes may be enlarged with a small nail.

After the plants have been removed from the seedbed they are treated, 40 or 50 at a time, in the following manner: the plants are laid on a flat surface, the stems above the roots and below the lower leaves, are sprinkled

lightly with water and a light coat of the dust is shaken on this moistened area. The plants are then turned over and lightly dusted on the other side. The treated plants are then placed in baskets and carried to the field for setting. It should be remembered that the maggot does not start feeding on the roots or aboveground, and that the proper place to apply the calomel is on the stem above the roots and below the leaves.

An older method of control is still practiced to a considerable extent on Long Island. A mixture of tar and sand is applied around the base of each plant to prevent the flies from laying eggs there. To be effective, the mixture must be applied close to the plant in order to fill the crevices around the stem. The results obtained by using tar and sand are not so satisfactory as those obtained from treating the plants with corrosive sublimate or calomel, and Long Island growers are gradually adopting this latter method of control.

Control on radishes

Radishes are especially subject to infestation by root-maggots. Here the damage is measured, not by the decrease in thrift of the plants or by the size of the crop as a whole, but by the proportion of radishes infested by maggots.

It is often possible to grow radishes comparatively free from maggots by adopting certain preventive measures, such as early planting, so that the crop matures before June 1, planting far from any fields heavily infested by maggots the previous year, and increasing the size of the planting to a point where the proportion of infestation is relatively small. In small plantings or where the growing period coincides closely with the egg-laying activity of the flies, control measures are often necessary to protect the radish crop from infestation.

Good control of maggot injury can be obtained by the use of corrosive sublimate. Corrosive-sublimate solution, 1 ounce in 10 gallons of water, is applied to the plants at the rate of about 1 gallon to 30 feet of row. The solution should be applied in such a way that the soil immediately about the plants is moistened by the liquid. The first treatment should be made as soon as all the plants are well through the ground, and one or two later applications should be made at intervals of about a week. In some cases one treatment will be found to give ample protection from the maggot, but usually it is safer to make two applications; if the crop is making a slow growth, three applications are sometimes needed to insure complete freedom from injury.

Under certain conditions a suspension of calomel, 1 ounce in 10 gallons of water, can be substituted for the corrosive-sublimate solution in treating radishes. It is applied in the same way as is corrosive sublimate, but al-

most constant agitation of the solution is necessary to prevent the particles of calomel from settling to the bottom of the container. Calomel is safer to use on young radish plants than is corrosive sublimate, especially where severe flea-beetle injury is present. Under such conditions corrosive sublimate is likely to injure the plants more or less. Calomel has the further advantage of remaining effective in the soil for a longer period. If the quantity of calomel be increased to 3 or 4 ounces to 10 gallons of water, a single application may be expected to give the same protection as two or even three treatments with corrosive sublimate.

BLIGHT

(Caused by *Bacterium compestre*)

Blight attacks many cruciferous plants, including cabbage, Chinese cabbage, cauliflower, brussels sprouts, collards, kohlrabi, rutabaga, radish,

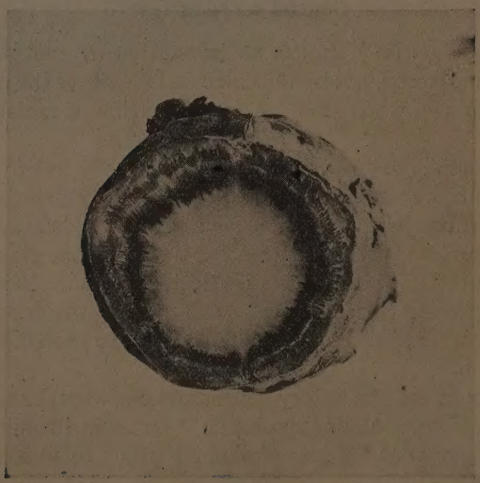

FIGURE 1. A DARK RING IN A CABBAGE STEM CAUSED BY BLIGHT

broccoli, kale, mustard, stocks, turnips, and most other members of the mustard family. The bacteria live on the seed or in the cabbage refuse in the soil, and after gaining entrance into the seedling cause a yellowing or browning of the foliage, which shrivels and dies. Young plants may be killed outright, but in older plants the organism merely blackens and kills the veins through which it advances. It also produces a typical black ring in the stem. The lower leaves may drop off, and the heads are dwarfed or

one-sided, and later may decay, falling off in a slimy heap. For this reason it sometimes is named *stump-rot.*

Control

Refer to control of black-leg, page 12.

BLACK- LEG

(Caused by *Phoma lingam*)

Black-leg may result in almost the complete loss of the cabbage crop. Aside from cabbage it affects also cauliflower and most of the other crucifers mentioned under blight. The first symptom is the sunken area on the stem near the ground line. The areas extend in size and depth until the stem is girdled. Small black dots, the fruiting bodies, develop within the lesion

COURTESY OF J. G. HORSFALL

FIGURE 2. DIFFERENCE IN STAND FROM SEEDLINGS FROM A HEALTHY SEEDBED (LEFT) AND FROM A SEEDBED INFESTED WITH BLACK-LEG OF CABBAGE (RIGHT)

and bear innumerable spores. The spores are splashed by rain, or possibly carried by insects, to neighboring stems and leaves, where new infections arise. The fruiting bodies develop upon the affected leaves the same as upon the stem, so that their presence in the dead areas is an excellent diagnostic symptom. The organism may live for at least three seasons in the soil, and is carried on and in the seed.

When infected seed is planted, the cotyledons, pushed above the soil by the stem, serve as a fruiting place for the parasite. Infection also occurs at the base of the new stem from the mycelium harbored under the seed-coat. Dissemination and inoculation take place rapidly. A few infected seeds may be the source of an epidemic later. A common method by which this is brought about is the practice of pulling up a large number of young plants and placing them together in water. If spores are present, every seedling may become contaminated under such conditions.

The Phoma is very susceptible to environmental conditions. In the Puget Sound district, where the rainfall from May to July is extremely light, there is very little of the disease present. In New York State it may be rare for several seasons, then become epidemic in nature. The severity of the disease is in direct proportion to the amount of rainfall in the early summer, and is worse when the rainfall is greatest.

Control

Since the fungus remains alive in the soil at least three years, it is necessary to practice at least a four-year rotation, bearing in mind that rape, kale, turnips, wild mustard, and many cruciferous weeds also are susceptible hosts. The diseased stalks and leaves should not be fed to cattle, and great care should be exercised to prevent the spread of diseased cabbage refuse to other parts of the farm. If one field is diseased and another is healthy, it is a good plan to use different sets of tools in cultivating the soil of each, for the fungus may be carried readily from one place to another on the tools. No seedlings should be transplanted from a seedbed which shows even the slightest infestation. A number of the eastern seed growers are exerting every effort to grow cabbage seed free from Phoma, so that as time goes by it will become easier to procure clean strains of cabbage. In the meantime only treated seed should be planted. Fortunately the seed can now be bought already treated or will be treated carefully by the farm bureau at a nominal charge. It has been proved that the treatment is beneficial to the crop even when blight and black-leg have not been present. The growers who live in counties where the farm bureau furnishes the hot-water-treatment service should by all means take advantage of this opportunity of freeing their cabbage, cauliflower, and brussels-sprout seed of black-leg.

DOWNY MILDEW OF RADISH AND CABBAGE

(Caused by *Peronospora parasitica*)

A downy mildew occurs on nearly every species of cultivated and weed plant that belongs to the mustard family. Fortunately for the grower, each crop has a distinct strain of the fungus, so that the one on cabbage, cauliflower, or any other related crop will not attack radish.

The disease appears as a slight yellowing on the upper side of the leaf. In moist weather a white mildew appears on the corresponding lower sides. The spot enlarges until the leaf dies. In severe cases the whole radish plant or cabbage seedling may be blackened. On older cabbage plants only the outer leaves are usually affected.

The fungus reproduces very rapidly, and enters the plant quickly. It overwinters in the soil as fungous threads and as oospores, and probably also is carried in the seed. It is not known how long the organism can live in the soil without a host crop.

All downy-mildew fungi are sensitive to weather conditions. The spores will not germinate unless the air is saturated with water. Furthermore, the low temperatures of the night permit the spores to germinate, and the higher temperatures of the day enables the germ tube to enter the radish leaf. Conditions for the development of the fungus are almost ideal in a cold frame that is not properly managed.

Control

The cold frame should be run as suggested for the control of damping-off (page 81). In addition, if mildew has been prevalent in the hotbed or cold frame, the plants should be sprayed at about five-day intervals with bordeaux mixture 2–2–50 or dusted with copper lime dust 15–85. The applications are begun as soon as the true leaves appear and are continued until the danger of mildew infection is passed. The bordeaux mixture and the dust must not be too concentrated or the radish plants will be stunted.

If there is a probability that the field of cabbage, cauliflower, or turnips will have too much mildew, a fertilizer high in superphosphate and relatively low in potash, such as a 4–12–4 or some similar formula, will reduce the amount of the disease. For cabbage and cauliflower, the seed should be treated as suggested for black-leg (page 12).

BACTERIAL LEAF-SPOT

(Caused by *Bacterium maculicola*)

Bacterial leaf-spot occurs in most cauliflower fields and sometimes also in cabbage fields. The leaves may be covered with numerous small brown or purple spots, ranging in size from mere points to ⅛ inch in diameter.

When badly diseased, the leaves turn yellow and drop off. The spotting may occur also on the white part of the cauliflower. The greatest loss, however, is in the cauliflower seedbed, the plants of which may appear as darkened bunches when the air, under glass, is saturated with water, which permits the disease to spread rapidly from centers of infection.

The disease is caused by a bacterium that is disseminated on the seed and in diseased plant parts. In the presence of moisture the parasite enters the breathing pores of the leaf, where in from three to six days visible infection occurs. It grows best at medium temperatures, but does not develop when the air is much above 84° F.

Control

When the disease has been severe, the control measures consist in changing the location of the hotbed, in at least a two-year crop rotation in the field, and in treating the seed as suggested for the control of black-leg (page 12).

STRIPED CABBAGE FLEA BEETLE

(*Phyllotreta vittata* Fabricius)

The striped cabbage flea beetle is about 1/12 inch in length, black in color, and marked with a wavy yellowish stripe on each wing cover. The larvae of this beetle feed on the roots of cabbage, radish, and wild mustard. The beetles hibernate in sheltered places and appear in the spring in cabbage seedbeds, where they may cause great damage to the young seedlings soon after they appear aboveground. When abundant, the beetles may even work their way down below the surface of the ground and destroy the young plants before they come up.

Control

In seedbeds, if heavy applications of fine tobacco dust high in nicotine were made when the plants first begin to appear, seedlings would usually be protected from severe injury. Tobacco dust is particularly valuable if applied to the seedbed when the soil begins to crack above the row as the young plants push through the ground. This treatment may be repeated at intervals of from four to five days to one week, depending on the amount of rainfall. Later the young plants may be kept thoroughly coated with a 4–4–50 bordeaux spray to which lead arsenate has been added at the rate of 2 pounds to 50 gallons of spray.

Flea-beetle injury often may be greatly aggravated by the application of corrosive-sublimate solution for maggot control, and this treatment should be omitted where beetle injury is severe. In such cases, particularly if there is much stem injury, a suspension of calomel should be substituted

for the corrosive-sublimate treatment for maggot control. In attempts to protect the cabbage seedbed from flea-beetle injury by the application of insecticides, the tendency is always to begin the treatment too late, and injury is often severe before even an experienced grower realizes what is happening.

CLUBROOT

(Caused by *Plasmodiophora brassicae*)

Plants affected with clubroot have yellowish, sickly leaves or green leaves that wilt on hot days. Young plants may die outright and older ones may fail to produce marketable heads. Roots of such plants are much enlarged and malformed. These malformations vary in size from very small swellings on smaller roots and rootlets to large clubbed masses, often cracked and furrowed on their surface, that later decay and give off bad odors.

The disease is caused by a parasitic slime mold that gains entrance through root hairs and injured roots. After the swelling of the roots is produced, the body of the slime mold is transformed into a mass of spores which are released into the soil upon the decay of the host tissue. The spores are disseminated by any means in which infested soil or soil water may be carried, and with contaminated manure. They are never carried on or in the seed. The organism is reported to be able to live in the soil for a period of at least seven years and to attack susceptible plants at any time during this period. Wet and acid soils are favorable for the propagation of the parasite.

Control

The eradication of weeds that belong to the mustard family, the choice of well-drained soil, the elimination of all seedbeds that show clubroot, and the practice of long crop rotations, are sound recommendations of long standing.

The seedbed is very important in the dissemination of the clubroot organism. For this reason the first real step in control is the location of the bed in an area where no diseased cabbage has ever been grown, where no contaminated manure has been applied, and where no infested soil can be washed. In past years the application of lime to the seedbed has been recommended if there was a possibility of clubroot infection. This advice has been withdrawn because it has been found that the lime in the seedbed merely hides the presence of the disease and does not protect the plants when they are removed from the infected soil and set into an acid soil in the field.

Fortunately corrosive sublimate will disinfect the soil about the roots of the seedling plant, and thus will hinder clubroot infection even when the

FIGURE 3. CLUBROOT AS IT APPEARS ON THE SEEDLINGS IN THE SEEDBED

slime mold is present. The new recommendation, then, is to treat all cabbage, cauliflower, and brussels-sprouts beds with corrosive sublimate as outlined under the control of cabbage root-maggot (page 6). If the disease promises to be severe, as many as five applications may be necessary in the seedbed, beginning as soon as the plants are through the ground, and repeating the application at weekly intervals.

It would be an impossibility to treat the plants in the field often enough with the mercury compound to control clubroot. But this is unnecessary since hydrated lime has proved equally effective here when applied six or more weeks before the plants are set into the field. After the ground is plowed, enough hydrated lime, or quicklime if preferred, is scattered and harrowed in to produce an alkalinity slightly above neutral (pH 7.2). The county agricultural agent or the soils specialists by making tests can determine the amount to apply to any given field. In some cases only a few hundred pounds are necessary, while in others as much as three tons may be required. The points in the scale of alkalinity where infection is still abundant and where control is absolute are so close together that it is possible to apply almost enough lime and seemingly get no benefits from

it. Therefore it is important that each grower have a test made of his soil, and then add enough lime to make sure that the soil reaction will be above the neutral point. If the soil is already neutral when tested, 1500 pounds of the hydrated lime are still required to furnish the presence of the hydroxide form of lime, which is needed for inhibiting the growth of the organism.

The type of lime used is important. It has been proved by experiments that only quicklime or hydrated lime can be used profitably in the control of clubroot. For some reason not yet explained, ground limestone or air-slaked lime will not stop the growth of the slime mold until the soil has been made too alkaline for good growth of cabbage. Consequently, ground limestone and air-slaked lime are not recommended. For the same reason spring rather than fall applications are advised. If hydrated lime is applied long before the crop is planted, the lime changes to the carbonate form which is ineffective in controlling the disease. The percentage of calcium in the hydrated lime is not important as long as it is not air-slaked. In other words, if lime with a high percentage of magnesium can be bought more cheaply, it can be used satisfactorily so far as clubroot control is concerned.

CABBAGE WORMS

(*Pieris rapae* Linnaeus)

The velvety green caterpillars that attack the leaves of cabbage, cauliflower, and related plants are the larvae of the common white butterfly seen flying about the field from early spring till late autumn. The butterfly deposits its eggs singly on the undersurface of the leaves. The eggs hatch in about a week, and the young larvae feed at first on the underside of the leaf which they skeletonize. Later the larvae move about freely on the plant and eat out large irregular holes in the leaves, and often penetrate into the head itself. They become full-grown in from ten days to two weeks, and then transform to the chrysalis, or pupal, state in some sheltered place. In New York three broods develop annually.

CABBAGE LOOPER

(*Autographa brassicae* Riley)

The cabbage looper is a pale green caterpillar marked with two dorsal stripes and a white stripe on each side of the body. It crawls about with a peculiar looping motion like a measuring worm. The looper feeds on the leaves and bores into the heads much as does the common cabbage worm, but, being somewhat larger and a voracious feeder, the injury inflicted is often more severe.

The winter is passed in the pupal stage in the ground. Apparently there

is a high mortality of the overwintering pupae, for the moths of the spring brood are rather scarce and the first brood of larvae attract comparatively little attention except occasionally in seedbeds on Long Island. There are said to be three generations annually in southeastern New York. The greatest injury is caused by the last brood of larvae, and this injury may be severe, especially on cauliflower.

DIAMOND-BACK MOTH

(*Plutella maculipennis* Curtis)

Another caterpillar that sometimes injures the foliage of cabbage, cauliflower, and related plants is the larva of the diamond-back moth. This moth has an expanse of about 5/8 inch. Its name is derived from the form of the markings on the wings of the male, which, when the wings are closed, form a row of three diamond-shaped spots. The insect hibernates in the adult stage, the moths seeking shelter under cabbage leaves or other trash left in the field. The moths emerge in the spring and lay their eggs on the leaves. The eggs hatch in about a week, and the young larvae feed on the underside of the leaf. They eat into the leaf from beneath but do not cut holes all the way through. Later, however, the epidermis dies and falls out over these injured areas, leaving the leaf riddled with holes. When mature, the larva is about 3/8 inch in length, pale green in color, and its head is brownish yellow mottled with black. There are two or three generations annually in New York. Cabbage and cauliflower seedbeds are liable to infestation. In the field, cabbage is more likely to be injured early in the season while the plants are small, but in the case of cauliflower the late broods are usually the most destructive. On Long Island larvae and moths often remain abundant on both cabbage and cauliflower till November or early December.

Control of cabbage worms, cabbage looper, and diamond back moth

It is unsafe to use arsenical or fluorine poisons on cabbage, cauliflower, brussels sprouts, broccoli, kale, or similar crops. If the grower uses an insecticide bearing a trade name or brand, he should make sure that it does not contain either of these poisons. Leaf-eating caterpillars on these plants can be controlled by applying a dust containing ½ of 1 per cent of rotenone, at the rate of about 25 to 30 pounds to the acre according to the size of the plants. The dust should be applied evenly under favorable weather conditions, taking care to reach the worms in the center of the plant. The dust can be applied most economically with a power duster or hand duster according to the size of the planting.

CABBAGE APHIDS

Two kinds of plant lice infest cabbage and cauliflower on Long Island, the spinach aphis and the cabbage aphis.

The spinach aphis

(*Myzus persicae* Sulzer)

The spinach aphis, a rather small, yellowish green insect, is the important species that attacks cabbage and cauliflower on Long Island. Infestation may become serious in the seedbed, and after the plants have been set in the field they may be seriously stunted by the lice.

Control

The most practical method of controlling the spinach aphis in the field is to dust the plants with a 2- or 3-per-cent-nicotine–lime dust. The plants should be freed of all lice before they are transplanted by an application of the dust. This may prevent, or at least delay, a serious infestation in the field. Plants grown in the South are pretty likely to be infested. Such plants can be freed of the lice by dipping the tops in nicotine solution, using 2 ounces of nicotine sulfate, ½ pound of soap, and 10 gallons of water. The roots must not be dipped.

The cabbage aphis

(*Aphis brassicae* Linnaeus)

The true cabbage aphis, so destructive in up-state New York, is only of minor importance on Long Island, except on late cabbage and brussels sprouts. The bodies of this aphis are covered with a whitish, waxy bloom that give them a grayish appearance. They become closely crowded together in dense masses, often covering large areas on the undersurface of the leaves. The presence of the lice causes the leaves to curl, often producing deep pockets filled with masses of insects. Badly infested plants are weakened, stunted, and may be killed outright. The formation of a good head of cabbage or brussels sprouts is prevented, and the size and the quality of the crop are greatly reduced.

Control

Under Long Island conditions the cabbage aphis may be controlled by the same measures as the spinach aphis. It pays to watch the field closely and, as soon as the lice are found, to dust thoroughly each infested plant and adjacent plants with a 4-per-cent-nicotine–lime mixture using a hand duster. This is known as *spot-dusting*, and will often prevent a general infestation of the crop.

THRIPS

(*Thrips tabaci* Lindeman)

Cabbage, cauliflower and brussels-sprouts seedbeds, are liable to infestation by thrips. This is the species also known as the *onion thrips*. These minute, elongate, yellowish insects attack the young plants soon after they come up. Thrips first appear on the undersurface of the leaves along the midrib near the base. In feeding, they rasp off the surface of the leaf and suck up the exposed juicy parts. The injured areas of the leaf present a dried, scarified appearance. When the injury is severe, the whole undersurface takes on a dirty brownish color. Injury from thrips is more likely to occur during periods of dry, hot weather.

Control

In the seedbeds thrips can be controlled by spraying with nicotine sulfate, ½ pint, and soap, 3 pounds, in 50 gallons of water or by dusting with 3-per-cent-nicotine-lime dust. Great care should be taken in making the applications to hit the thrips with the spray or the dust.

It is sometimes necessary to treat cauliflower plants for thrips after they have been set out in the field. A 3-per-cent-nicotine-lime dust can be used for this purpose. It should be applied with a power duster. To be effective, the duster should be equipped with a canvas trailer, 20 to 30 feet long, to confine the dust and cause it to settle on the plants. To be most effective, the dusting should be done when the temperature is high and when there is little wind. During the heat of the day, the plants are more limp than at any other time and are less likely to be broken off by the trailer. Spraying with nicotine sulfate and soap is sometimes resorted to and is very effective, provided the nozzles are arranged so that the underside of the leaves are entirely covered with the spray.

WHIP-TAIL, OR MALNUTRITION, AND TIPBURN

(Caused by unfavorable environmental conditions)

During certain seasons much whip-tail on cauliflower plants and tipburn on Danish Ballhead cabbage are observed; in some fields these diseases occur almost every year. The two troubles are related in that they both are produced by malnutrition.

Whip-tail on cauliflower manifests itself in a change of the normal green of the leaves to a light green or yellow between the veins and around the margins or in making the leaves more narrow than normal. The lower outer leaves are first and most severely affected. Later the upper inner leaves also show the abnormality. The injured leaves have a "quilted" appearance, are thicker than are the healthy ones, and so brittle as to be

easily crushed between the fingers. The seriousness of the injury to the plant may vary from the production of a full-sized head to the entire absence of one.

In tipburn of cabbage the tips of the leaves show brown or black mar-

Figure 4. tipburn of cabbage

gins. When the trouble is slight, only the margins of the outer, older leaves are affected; in a greater manifestation the outer leaves may be entirely dead, and the margins of the younger ones distinctly tipburned. In the more pronounced cases the whole plant is somewhat dwarfed and the head is not firm.

Control

No parasitic organism is connected either with the whip-tail or the tipburn. The trouble on the cauliflower may be produced in various ways, but commonly it is the result of an acid soil. When the disease occurs, a soil test should be made at once, and, if necessary, enough lime should be applied far enough in advance of the planting season to get a soil reaction nearly neutral.

Even though lime is present whip-tail may affect the plants. It is then possible that the ratio of superphosphate and potash in the fertilizer is not correct. It has been found that where whip-tail seems to persist, the condition can be improved by decreasing the amount of superphosphate and increasing the amount of potash. For instance, if the formula 4–12–4, 4–16–4, or even 5–10–5 has been used, it may be well to try a 5–8–7 or a similar ratio. This is true particularly on farms that have been fertilized heavily each year with superphosphate until there seems to be a surplus of the material in the soil.

The tipburn apparently is not influenced much by the presence or the absence of lime, but it is increased by too great a supply of superphosphate. The 5–8–7 ratio seems to be the correct one to use where the tipburn is likely to be present. Only when growing Danish ballhead is it necessary to take this precaution, as early and kraut varieties of cabbage seem very resistant to the trouble. This recommendation does not suggest a change in fertilizer practices from that recommended generally by the horticulturists except when tipburn is severe enough to cause injury.

BEANS

A large proportion of the bean crop is destroyed by insects and diseases; therefore special care should be taken in procuring healthy seed, in taking precautions against the seed corn maggot, in long rotations to avoid root rots, and in spraying or dusting if the Mexican bean beetle or the downy-mildew is present.

ANTHRACNOSE

(Caused by *Colletotrichum lindemuthianum*)

The most characteristic symptoms of anthracnose are the black, sunken cankers on the pods. In the center of the lesions is a salmon-colored ooze. Similar lesions are found on the cotyledons of the young plants and on the

stems. The most noticeable symptoms on the foliage are the blackened, dead portions of the veins on the underside of the leaf. The stems may be rotted off just as they emerge from the ground or the cotyledons may be destroyed. In either case the plant dies or becomes worthless. Later infections harm mostly the pods and their seeds. The mature infected seeds may or may not be discolored.

The organism causing the anthracnose is carried over winter in the bean seed and in the diseased bean refuse left in the field or in the bean straw. It does not live long in the soil without beans and is not known to attack any weed hosts or other farm crops. When affected seeds are planted, the organism is pushed aboveground on the cotyledons, and from there it is scattered by the splashing and washing of rain, by insects, and on tools and clothing to all parts of the field. It grows through the pods and affects the new seed beneath the spot.

The disease is influenced much by the weather, and is worse in rainy weather when the soil is wet, the humidity of the air is high, and the temperature is between 63° and 75° F. Water must be present before the spores are liberated.

Control

Satisfactory control measures have not been found for all varieties of beans, especially those that are very susceptible. There are certain general recommendations that have proved beneficial, such as plowing under in the fall all diseased refuse, practicing rotations with other crops, using well-drained soil, refraining from cultivating the field when the plants are wet, and keeping the field free of weeds so that the plants will have good air drainage.

The principal control measure, however, consists in procuring healthy seeds or those that are resistant to anthracnose. Since the seeds in a pod without cankers are healthy, good seed can be obtained by picking the required number of healthy pods and saving the beans for planting next year's crop. If healthy stock of this type is planted in a field which is isolated from diseased plants, the resulting crop will be healthy.

Another method of procuring healthy seed is to have it shipped from some State or country where, because of weather conditions, the disease does not occur. At present nearly 90 per cent of the Red Kidney seed planted in the State comes from the Sacramento Valley in California or from Idaho. Certain areas in these two States are free from both anthracnose and bacterial blight. Much of the snap-bean seed is grown in Idaho, and is satisfactory from the standpoint of freedom from anthracnose. Therefore, each grower should insist that his snap-bean seed be grown in Idaho rather than in the East. It, too, would be well for the same reason to procure the lima bean-seed from California where so much of the seed is grown.

The most satisfactory means of control is to breed or select resistant varieties. This work is now being conducted on a large scale and promises to increase materially the resistant strains that already are available. The fact that there are in New York State at least three strains of the anthracnose fungus, each one differing in its ability to cause infection, complicates the matter of breeding and selection. A variety that is resistant in one locality may be susceptible in another where there is a different strain of the parasite. Resistant varieties among the snap beans are still few in number, but there is much hope for the future in the large number of strains that now are being bred.

BACTERIAL BLIGHT

(Caused by *Bacterium phaseoli* et al.)

This disease in some of its symptoms may be confused with anthracnose, although all mature lesions are quite distinct. At least three prominent injuries are produced on an infected plant. Large brown blotches, often bordered by a yellow or reddish halo, are the distinctive symptoms on the leaf. The whole leaf later may die, and defoliation of the plant takes place. The second symptom is caused by a girdling of the stem at one of the lower joints, so that the whole plant wilts or falls over, and is sometimes known as *tip-over*. The third pronounced symptom is the canker on the pod. This rarely is circular as in anthracnose, and never is coal black or deeply sunken. The blight causes rather indefinite, water-soaked spots, usually with reddish margins, on the pods. At times a white or yellow ooze may appear on these affected parts. The infected seed may be discolored, but more frequently it is not.

The bacterial blight is caused by any one of six nearly related bacterial species and varieties whose life histories are practically the same. The organisms overwinter in the seed and in the bean refuse in the field or in the bean straw. Their life histories, so far as the infection of the young plants and the spread of the disease are concerned, are the same as for the anthracnose fungus. In addition, the bacteria may enter the plant at any point and pass entirely through the water ducts without causing symptoms on the outside. Thus bacterial blight is spoken of as being *systemic* in nature. For this reason it is impossible to say whether beans are free from the disease even though the pods in which they grew looked perfectly normal.

Control

The general control measures for blight are the same as those given for anthracnose, including the use of Idaho-grown seed (page 23). But the problem of harvesting healthy seed or the breeding of varieties resistant to

bacterial blight is far more complicated than when only anthracnose is concerned. Since the disease is systemic, the bacteria may enter the seed by way of the water ducts, and furnish no sign of their presence. Therefore pod selection for the control of blight is out of the question. Furthermore, there are no fully resistant varieties that can be used in breeding resistant strains.

Neither spraying nor seed treatment has proved effective in combating the anthracnose and the bacterial blight.

MOSAIC

(Caused by a virus)

The bean leaves affected with mosaic have irregular light yellow areas merging with dark green patches, producing the characteristic mottling, or mosaic, effect. The darker areas develop faster than do those having the yellow tinge, with the consequence that the leaf is much puckered, especially along the midrib, and the edges are cupped downward. The affected plant may have a sickly yellow color; nevertheless it remains alive until the end of the season. Early infected plants rarely bear any seed even though they may continue to blossom until autumn.

Mosaic is caused by a virus which overwinters only in the bean seed. The virus is carried from one plant to another by sucking insects, by rubbing one leaf against another, and in any other manner that sap from one plant may be transferred to the other.

Infection is favored by high temperature and high humidity at the time of inoculation.

Control

Among the snap beans the Refugee types are the most susceptible. These are rather generally grown by canners, and as most of the seed comes from Idaho it is not uncommon to find from 20 to 50 per cent infection in any given field. The common market gardening beans are much more resistant, and can be grown under ordinary conditions without fear of any pronounced reduction in yield.

A number of bean varieties are more or less resistant, and are being used successfully in developing new strains of the more desirable but susceptible varieties.

Seed treatment and spraying or dusting are of no value in the control of mosaic. It has been suggested that if seed is kept for several years, the virus will die and a healthy crop can be grown from this seed. This idea is erroneous, for the virus will remain active as long as the seed is alive.

DRY ROOT-ROT

(Caused by *Fusarium* spp.)

The root-rot affects directly only the roots of the common and lima beans; but the parts aboveground are stunted, may turn yellow and wilt, and usually die before the plants mature. If infection is only moderate and rather general, the plants may remain alive until harvest, but the whole field will have the appearance of being undernourished. The plants may be affected as soon as they emerge from the ground; usually, however, the trouble is more common on the older plants. When these are pulled up, the side roots are found to be rotted away, and the taproot has turned brick red and is hollow and dry. New side roots may be forming on the stem above the lesion.

The root-rot is caused by a fungus that lives in bean refuse and also in the soil for several years. It grows into the roots and up through the water ducts, thereby causing the plant to wilt. The fungus rarely fruits until the affected stems or roots are old and have started to decompose. The spores and the mycelium are carried into the soil on tools and horses' hoofs and in bean straw. They also may be splashed by rain or carried by floods. In spite of all these methods of dissemination, the fungus spreads rather slowly.

Probably the fungus affects no other crop. A Fusarium that occurs on the pea looks very much like the one on the bean, but the two are distinct so far as the hosts are concerned.

The root parasite is not influenced much by moisture, but is aided by a high temperature. Its best growth is at 86° F. A too alkaline soil also favors dry root-rot.

Control

When putting into practice root-rot control measures, it must be kept in mind that the pathogene is not seed-borne, but that it is strictly a soil organism. Since it is carried with the bean straw, the bean refuse should always be hauled to the part of the farm where beans probably never will be grown, or placed in fields where beans will not be grown for six or more years.

It is not known how long the root-rot fungus can live in the soil. It has been demonstrated, however, that where a six-year or longer rotation is practiced, the disease is held in check sufficiently to grow profitable crops. On the other hand, it has been shown that where the usual three-year rotation is practiced, root-rot increases until finally bean growing in those fields becomes an impossibility.

Aside from the correct disposal of the bean straw and long rotations, a few general recommendations are made: Any diseased bean refuse left on

the field should be turned under deeply by fall plowing. Beans should be planted only on well-drained, well-fertilized soil that is medium in the scale of alkalinity, and which has enough humus for retaining soil moisture. Cultivation should cease as soon as root-rot once appears. If the base of the plant rots off and new side roots form above the lesion, the plant may live if the newly formed roots are not cut off by the cultivator. The more plant food available in the soil, the faster these side roots will form and the more chance there is for recovery.

Seed treatment and spraying are of no value in the control of root-rot. Unfortunately, also, no very resistant strains have been found from which suitable types could be bred.

MEXICAN BEAN BEETLE

(*Epilachna corrupta* Mulsant)

The Mexican bean beetle passes the winter in the adult condition, often at a considerable distance from the bean field. The hibernating beetles can be found under piles of rubbish, in the drifted piles of leaves along fence rows, under the fallen leaves at the edges of woodlots, and in similar situations. The beetle is about ⅓ inch in length, oval in outline, strongly convex above, and pale yellowish to brownish in color. The eyes are black, and each wing cover is marked with eight small black spots arranged in three transverse rows. The beetles appear in the bean fields about the time the plants put out their first leaves. They feed on the foliage, mostly from the underside, eating holes in the leaves. The eggs, which are about 1/20 inch in length, oval in shape, and yellow in color, are deposited on end, in clusters of from 40 to 60, on the underside of the leaves. They hatch in from six days to two weeks, depending on the temperature. The larvae feed on the underside of the leaves, leaving the upper epidermis and a network of tissue and veins. The injured leaves dry up, and in severe cases the plant is killed. The larva passes through four stages in the course of its development and becomes full-grown in from three to five weeks. It is then about 2/5 inch in length, light yellow in color, and clothed with stout branched spines. When mature, it attaches the tip of its body to the leaf and transforms into a yellow pupa about ⅓ inch in length. The pupal period occupies about a week. The entire life cycle is completed in from four to seven weeks, depending on the temperature. Under New York conditions two generations develop annually.

Control

Arsenical poisons may be used for the control of the Mexican bean beetle early in the season, but they should not be used after the pods begin to form. Magnesium arsenate is the most satisfactory arsenical for this

purpose; if it cannot be obtained, calcium arsenate may be substituted, although it is somewhat more likely to injure the foliage. These arsenicals may be applied either as a spray or dust. Insecticides are effective against the bean beetle only when applied to the undersurface of the leaves.

For string beans up to blossoming time

Spray formulas

Use 100 gallons per acre.

Magnesium arsenate	3 pounds
Water	100 gallons

Add either 3 pounds of caseine spreader, or 3 pounds of flour paste, or 3 quarts of skimmilk, and ½ pound hydrated lime.

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	3 pounds
Hydrated lime	9 pounds
Water	100 gallons

Dust formulas

Use 30 pounds per acre.

Magnesium arsenate	20 pounds
Hydrated lime	80 pounds

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	15 pounds
Hydrated lime	85 pounds

For lima beans up to blossoming time

Spray formula

Use 100 gallons per acre.

Copper sulfate	8 pounds
Hydrated lime	8 pounds
Magnesium arsenate or calcium arsenate	3 pounds
Water	100 gallons

Dust formula

Use 30 pounds per acre.

Monohydrated copper sulfate	15 pounds
Magnesium arsenate or calcium arsenate	15 pounds
Hydrated lime	70 pounds

The first treatment for the beetle should be made when the eggs begin to hatch or sooner if the beetles are abundant and are causing injury. Usually two applications of the spray or three treatments with dust are required.

After the pods begin to form neither arsenicals nor fluorine compounds should be used on beans. If it is necessary to fight the insect at this time, pyrethrum or rotenone dusts should be used. It is not advisable to attempt to combine rotenone with Bordeaux mixture, because in this combination the effectiveness of the insecticide is greatly reduced.

BEAN APHIS

(*Aphis rumicis* Linnaeus)

Beans are subject to attack be a small black plant louse. This species also infests beet, pea, celery, asparagus, orach, onion, leek, rhubarb, and horse-radish. Its commonest wild-food plants are dock, burdock, lamb's quarters, shepherd's purse, and pigweed. The winter is spent in the egg stage on a number of ornamental shrubs.

On beans this aphis can be controlled by thorough spraying with nicotine sulfate, 1 quart in 100 gallons of water in which 5 pounds of soap has been dissolved, or by dusting with a 4-per-cent-nicotine–lime mixture.

DOWNY-MILDEW OF LIMA BEAN

(Caused by *Phytophthora phaseoli*)

The most conspicuous symptom of downy-mildew is the white downy mold in patches or completely covering the bean pod. The fungus grows through the pod wall into the bean. The whole structure finally shrivels, dries, and becomes black. Such black dried pods are common in badly infested fields. The fungus attacks also the young shoots, the flowers, and the leaves. The tender branches and the flower-pedicels are distorted in shape and covered with the mold. The white mycelial weft appears very sparingly on the leaf, but the veins may be purplish in color, twisted, or otherwise distorted.

The time of incubation of the fungus is so short, the amount of inoculum so abundant, and the means for dissimination so nearly perfect, that within a few days it can sweep over a planting and leave nothing but blasted pods. Much of the early infection comes from the diseased seed. Within a few days fruiting bodies are formed on the surface of the pod, the stems, or the leaves, and the life history is repeated. Bees or insects collecting nectar carry the conidia from diseased to healthy blossoms. The wind, too, is an important factor in dissemination, as are flowing water and the splashing of rain.

Cool weather and moisture are favorable for the development of the downy-mildew, as is attested by the fact that in a rainy season the fungus grows even after the first fall frosts. It is most abundant in the districts where the night temperatures are low and the midday temperatures are relatively high.

Control

After studying the life history of the parasite, it is evident that long rotations, destruction of the diseased vines in the autumn, and the selection of seed beans from a healthy crop, are three important steps in controlling the mildew. As a supplement to the above-named control measures,

spraying with bordeaux mixture, 4–4–50 or dusting with copper-lime dust, 20–80, is suggested. It is not advisable to make applications of the spray or dust while the beans are in blossom, except in cases of greatest emergency for the fungicide may then reduce the set of pods. Since the disease occurs only during certain years and the epidemic cannot be foretold, it is necessary to spray each year. Each grower must decide whether the loss of his lima beans has been frequent enough to justify his use of bordeaux mixture. In New York applications seldom need to be made before July 15. Three or four additional sprayings are made at weekly or ten-day intervals.

PEAS

Nearly all the diseases of peas are root troubles that require for their control well-drained soil, early planting, and long rotations.

The planting of healthy seed is recommended for the control of blight. and dusting is advised for pea aphis when necessary..

BLIGHT

(Caused by *Ascochyta* and *Mycosphaerella*)

There are really three blight diseases that attack the pea, but as the organisms causing them are so nearly alike, they are treated here as one. The blight is a very serious trouble that may cause as much as a 20 per cent loss of the pea crop in the State when conditions are favorable for the fungi. This disease is found in all States east of the Mississippi River but is rare or entirely absent in the far-western States and in western Canada.

The disease produces black to purplish streaks on the stem. The lesions are more pronounced at the nodes, where they enlarge into brown or purplish irregular areas and may extent as high as 10 inches above the roots. The leaves become spotted in various ways. In some cases the spots are small purplish irregular dots, while at other times they are fairly large, almost circular, and may have concentric circles in them. On very susceptible varieties the whole leaf may shrivel and become dry. The spots on the pods are similar to those on the leaves, except that on the fleshy pods they are sunken and do not have concentric rings. When the disease is severe, the plant may not emerge from the ground or, if it does push through the soil, it may be killed soon after. Older plants do not succumb to the disease but their yield is much reduced.

Since the pod spot resembles very much the anthracnose of beans, the diseases on the two crops were considered identical at one time. They are now known not to be related. The pea blight is caused by three fungi, the life histories of which are almost alike. They are carried in the seed,

and cause infection when the plant is emerging. Rains splash the spores to neighboring plants until a whole field is infected. The diseased seed and pea straw serve as means for the fungi to survive until the following season.

The optimum temperature for growth of the fungi is approximately from 75° to 80° F. A fairly rainy season is required for much dissemination of the disease.

Control

The general directions given for the control of root-rots (page 34) apply equally well to blight. Well-drained soil, plowing under deeply in the fall all diseased refuse, and long rotations particularly are needful in the case of blight. But the most important measure of all is the procuring of healthy seed. All stock grown in the eastern and central States may carry the fungi. Therefore, it is strongly recommended that seed be bought from the far West where irrigation or dry-land farming does not permit the growth of the pathogenes. If this is impossible and the source of the pea seed is not known, it is well to have the specialist at the state experiment station test the seed both for germination and percentage which have disease. A small cost is attached to this testing. The grower can obtain the details of the plan by applying to his county agricultural agent.

Seed treatment has not proved successful.

Many varieties have been tested for resistance, but none of them have proved to be nearly immune. Some of the varieties that were much less affected than others were: Admiral 17.78, Advancer, Badger Special, Champion of England, Horal, Horsford, and Perfection. Where blight has been severe and western seed cannot be obtained, it might be possible to try some of the above-named varieties. The problem is complicated by the fact that some of these are very susceptible to wilt. Horal is the only one that seems valuable in combating both diseases.

BACTERIAL BLIGHT

(Caused by *Bacterium pisi*)

The bacterial blight of peas was first described in Colorado, but has since been found in most of the other States, and even in other countries. It apparently never has caused great loss in New York State, but seems to be increasing, and an occasional field may be found that has suffered much injury.

The disease is found on all parts of the plant aboveground. The affected tissue of the stem assumes an olive-green to olive-brown color, and the stipules and the leaflets become yellowish or water-soaked. The trouble may show at any time in the growth of the vine. If the infection takes place before the peas are from 3 to 4 inches in height, the plants die

and wither, leaving only missing spaces in the drill row. In older plants the infection has its source an inch or more aboveground, the lesion gradually extending upward on the stem until the top wilts; finally the whole plant may succumb.

The spots on the pod have a water-soaked appearance at first. Later the lesion may turn yellow or brown. When dried, the lesion has a papery texture.

The bacterium is carried over long distances on or in the seed, and in the field is disseminated by splashing rain and in diseased refuse. It enters through the breathing pores, and especially through wounds of young leaves and pods.

Control

No direct control measures are known. Since high humidity and high temperature favor the organisms, peas should be sown early in the spring in well-drained soil. No efficient seed treatment has yet been devised for peas. Some attempt has been made to select resistant strains, but this also has not been very successful. The Alaska and the Telephone are two of the most susceptible; therefore where the bacterial blight has been serious, these varieties should be avoided.

PEA APHIS

(*Macrosiphum pisi* Kaltenbach)

The pea aphis is the most serious insect with which pea growers in New York have to contend. Fortunately it is intermittent in its attacks. The aphis is very sensitive to weather conditions, and years of great abundance may be followed by several seasons in which the insect does little or no damage. When abundant, however, it is capable of causing great damage and may even entirely ruin the pea crop over a considerable area.

The pea aphis is a rather large pea-green plant louse that harmonizes well in color with the plants on which it may be found. In addition to peas and sweet peas, it attacks clover, vetch, alfalfa, and sweet clover. On Long Island the insect probably survives the winter, in part at least, as an adult or partly grown nymph. In the spring the first generations of the lice are produced on the winter host plants,—clovers and alfalfa. After the first generation part of the lice are winged and migrate to other plants where feeding conditions are more favorable. Some of these migrating lice find their way to the peavines, and there start colonies. Reproduction is rapid, and soon the stems become covered with the lice. The leaves, the blossoms, and the pods are soon attacked. Infested leaves become slightly thickened and curled; infested blossoms are blasted; and injured pods are stunted, deformed, and rendered worthless. Badly infested plants take on a sickly yellowish appearance and may be killed outright.

Control

On peas planted in rows to be hand-picked, the lice can be greatly reduced in numbers by spraying or dusting with nicotine preparations. The spray is more difficult to apply and usually gives less satisfactory results. Better results are obtained from dusting the plants with a 3- to 4-per-cent nicotine-hydrated-lime dust, using from 30 to 50 pounds per acre, depending on the size of the plants and the denseness of the foliage. The application should be made when the temperature is above 70° F. and when there is little wind. The dust may be applied with a tractor or power duster. The nozzles should be set rather low and directed so as to envelop the plants in a cloud of dust. The effectiveness of the dust can be greatly increased by using a canvas trailer 30 feet in length, attached to the boom in front and allowed to drag over the peas as the duster moves forward. The trailer confines the dust to the vicinity of the plants and prevents its being blown away by the wind. When confined in this way, the fumes of the nicotine are much more effective in killing the lice. Furthemore, the trailer itself brushes many of the lice from the vines. They fall to the ground, and many are unable to regain the plants, especially if the sun is bright and the temperature is high. Dusting is much less effective when the plants are wet with rain or dew. It is not a good plan to apply the dust just before a rain if it can be avoided.

Nicotine dust is expensive, and one does not care to use it unless necessary. In order to avoid unnecessary or premature applications, it is best to wait till at least half of the plants are infested before making the treatment. The expense of dusting for the pea aphis may be considerably lessened by home-mixing the dust (page 85) or by using a self-mixing duster.

ROOT-ROTS

(Caused by *Aphanomyces euteiches* and others)

Pea root-rot is a very serious trouble in many sections where the crop is grown intensively. The various centers of infection are scattered throughout the field and gradually enlarge as the season advances. The disease causes a rotting of the roots and the parts of stem that are below the surface of the ground. The diseased roots first appear water-soaked, then become soft and light brown or yellowish in color. Finally the outer layers of host tissue decay and slough off, leaving only the slender central core. If one of the affected plants is pulled up from soft soil, the central core of the taproot and of some of the larger side roots will pull out as a long string. This peculiarity, together with the color of the lesion, helps to differentiate the root-rot from Rhizoctonia rot. If the plants are affected while still in the seedling stage, they usually lose their healthy color, slowly

shrivel, and die. If the plants are half grown or more when infection occurs and conditions are good for pea growth, there may be no symptoms of the trouble aboveground. The plants may continue to grow normally and produce a crop.

The root-rot is caused by several of the lower groups of fungi. If a diseased root is crushed and the tissue is placed under the microscope, hundreds of resting spores may be found. It is in this form that the fungus overwinters. In the spring these spores germinate either by means of a long fungous thread or by small spores that can swim about in the soil water. These, together with the summer spores, are extremely abundant and can be carried by running water, in soil that is moved, by splashing rain, and with diseased plant refuse. So far as is known, the fungus is never disseminated with the seed. When conditions are favorable and peas are grown successively on the same soil, or in short rotation, the pathogene grows luxuriantly.

The conditions most favorable for the Aphanomyces are: types of soil that hold the water readily, as stiff clay, or sandy soil underlaid with hardpan; plenty of rainfall; and fairly high temperatures.

Control

The general control measures are long rotations, use of well-drained soil, and planting as early as possible. In the long rotations, however, it must be kept in mind that the fungus can attack also vetch, alfalfa, and sweet clover. The rotations should consist of crops other than these, such as potatoes, corn, cabbage, timothy, and the common clovers.

Early planting in well-drained soil is especially important in the case of root-rot, for, if the plants can be grown to half their normal size before infection takes place, the crop will continue to develop. In many parts of the State the soil is much cooler and the possibility of rainfall is less during April than during May, June, and July.

No resistant varieties have been found, so that if the root-rot once becomes generally distributed over a farm, it would be well to grow other crops for a few years.

RHIZOCTONIA ROOT-ROT

(Caused by *Corticium vagum*)

Rhizoctonia is so common everywhere and affects so many plants that it is not surprising that under certain conditions it may cause serious trouble on peas. It affects mostly the base of the stem, where it causes a depressed reddish brown lesion that may or may not girdle the plant. It can be differentiated from the wilt in not producing a black or wedge-shaped lesion, and from the common root-rot by not leaving the central core of the root, which can be pulled out like a long string.

Rhizoctonia is very common on many hosts but probably only certain strains affect the pea. These live overwinter in the soil and in crop refuse.

The fungus requires wet weather and rather cool soil, so that there may be much Rhizoctonia root-rot in a year when there are many cold wet rains soon after the peas are planted.

Control

There are no direct control measures; crop rotations are helpful. Peas should not follow potatoes, cabbage, or beans. During most years there should be little trouble from the disease, since the plants will outgrow much of the injury if the weather becomes favorable for pea production.

POWDERY MILDEW

(Caused by *Erysiphe polygoni*)

Powdery mildew of peas may be present when the summers are warmer than usual. The foliage is coated on its upper surface by a white talcum-like mold. If the fungus grows fast enough, the leaves are injured and the whole plant may be dwarfed. The fungus is carried in the seed and probably also lives over in the old diseased refuse. It is only rarely that it becomes serious enough on Long Island to demand attention

An attempt should be made to procure seed from the far Northwest where the powdery mildew is usually not present. If clean seed is planted in soil that has not borne peas for two years, there should be no danger of infection. In some early work done in New Jersey, bordeaux mixture sprayed on the crop at frequent intervals was used. In New Mexico where the disease seems to be very virulent, the specialists recommend seed treatment and dusting the plants in the field with sulfur. The treatment consists in dipping the seed in hot water (133° F. or 56° C.) for twenty minutes, then cooling and drying it. The sulfur is mixed with hydrated lime in the proportions of 4 to 6, and the plants are dusted whenever the mildew begins to show. No control measures have been suggested for Long Island since the losses have hardly justified the expense of applying fungicides.

SPINACH

The nature of the spinach crop is such that very few satisfactory control measures for injurious insects and diseases are available at present.

SPINACH APHIS

(*Myzus persicae* Sulzer)

One of the serious enemies of spinach is a rather small yellowish green plant louse that often appears in countless numbers, especially in the fall. This insect is known also as the *green peach aphis* and the *green-fly* of

greenhouses. It passes the winter in greenhouses, on its foodplants out of doors where the climate is mild enough, and in the egg stage on peach, plum, cherry, and apricot. In addition to spinach it attacks cabbage, cauliflower, eggplant, turnip, radish, kale, mustard, beet, pepper, horseradish, celery, rhubarb, and lettuce. It is often associated with the pink and green aphis on potatoes and tomatoes. It thrives also on a number of common weeds, including pigweed, lamb's quarters, dock, shepard's purse, and many others.

As a spinach pest the aphis not only stunts the plants and greatly reduces the size and the quality of the crop but it also acts as a carrier for two serious diseases—yellows and mosaic. The potato aphis also aids in the dissemination of these diseases.

On spinach the aphis is likely to be most abundant in the fall when the cool weather slows up the activities of its parasites and its other insect enemies, but it may become troublesome at any time.

Control

The most practical method of controlling the spinach aphis on most crops is by dusting with a 2- or 3-per-cent-nicotine–lime dust. In the case of spinach, where the leaves lie close to the ground, it is necessary to have the nozzles of the duster carefully adjusted close to the ground and to use a canvas trailer to confine the dust. To satisfactorily control the lice, the application should be made when the plants are dry, when the temperature is above 70° F., and when there is little wind blowing. About 65 pounds of dust is required to properly treat an acre of spinach, using the ordinary type of nozzles and setting them as close to the ground as possible. A saving in material may be obtained by using a special arrangement of nozzles in which they are allowed to drag directly on the ground, and are connected to the outlet pipes by means of short length of rubber hose. With this arrangement and with the use of a canvas trailer, it is possible to reduce the quantity of dust to 40 pounds per acre and still obtain satisfactory results.

SPINACH LEAF-MINER

(*Pegomyia hyoscyami* Panzer)

The leaves of spinach, beets, and chard are subject to infestation by a white or yellowish maggot that mines in the tissue between the two outer layers, producing an irregular blotch. Several maggots are usually found in the same leaf, and often the blotches coalesce. The flies of the spinach maggot appear in the field in April or May. The female fly deposits her white, elongate eggs singly or in rows of two to five, side by side, on the underside of the leaves. The eggs hatch in from four to six days, and the young maggot works its way into the tissue of the leaf and starts to exca-

vate its mine. The maggot becomes full-grown in a week to sixteen days. It then deserts the leaf and enters the ground, where at a depth of from 2 to 3 inches it transforms to a puparium. From two or three weeks later the flies emerge and soon lay eggs for another brood of maggots. There are three generations a year and a partial fourth in central New York.

The spinach maggot is most troublesome when attacking spinach, chard, and beets that are to be used for greens. It is especially objectionable in spinach grown for canning.

Control

No practicable method of controlling the spinach leaf-miner has been devised.

DOWNY-MILDEW, OR BLUE MOLD

(Caused by *Peronospora effusa*)

The downy-mildew, or blue mold, is prevalent wherever spinach is grown. It may be absent during certain seasons and then later destroy whole fields or, by appearing year after year, it may constantly menace the spinach crop.

According to the statements in literature, the parasite affects not only spinach but also swiss chard, lamb's quarter, and other plants belonging to the goosefoot family, although none of the investigators seem to have conducted careful cross-inoculations.

The disease on the leaves is manifested by large—or sometimes small—spots, which are differentiated from the healthy tissue by their pale yellow color. Any part of the leaf or the entire surface may be included in the spotting. The diseased leaves are scattered on the plant, although the lower ones are first to be attacked. On the upper side of the leaf the spot is bare except in rare cases, while on the lower side the lesion is covered with a gray to violet-gray mold. The affected part finally decays or dries, and the whole leaf succumbs. In severe cases the entire plant is affected.

The blue-mold fungus fruits abundantly on the underside of the leaf. The spores are splashed by rains, and possibly blown by wind, to other plants. Thus infection continues at a rapid rate if the weather is favorable for the growth of the fungus. The leaves that are killed later may be filled with thick-walled resting spores that can live over winter. The following spring the new infections come from the parasite harbored in the old diseased refuse and also from the fungus that lives over in the seed.

The conidia, or spores, require a low temperature of 45° to 50° F. and plenty of moisture for best germination. They will continue to grow at higher temperatures. In other words, the mildew is most destructive during a rainy period when the nights are cool.

Control

There are certain general practices in alleviating the trouble, such as two- or three-year rotations, plowing under deeply all diseased plant refuse as soon as the crop is harvested, not crowding the plants too closely in the row, and in planting the seed in well-drained soil. If it were possible to select seed from a mildew-free field and to plant it in isolated fields, there would be no danger of the disease. It seems almost impossible, however, to be sure that the seed is not infected.

Since seed treatment and spraying or dusting have not given satisfactory results in controlling spinach mildew, the only other measure is to procure varieties resistant to the fungus. In various States, and on Long Island, selections have been made with fairly promising results. The one trouble is that the prickly seeded resistant types are not so acceptable in the market and first must be bred for improvement of the quality.

YELLOWS

(Caused by a virus)

Spinach yellows is known generally as *blight*, but *yellows* seems to be a better name since it describes the symptoms and is consistent with the term applied to a similar disease on other hosts. If the trouble once becomes established, it may cause very heavy losses of the crop.

The symptoms begin with some mottling, almost as in the case of mosaic, but as the disease progresses the symptoms become very characteristic. At first there is a slight yellowing of the young inner leaves, later they change to a yellow color, and finally die. The disease gradually spreads to the outer leaves, which in turn are changed to yellow. During this time the foliage curls and wrinkles. If the plant is affected when young, and it may contract the disease in the seedling stage, it remains much dwarfed. In the advanced stages of the disease, the plant dies.

The disease is due to a virus which is transmitted from diseased to healthy plants by means of potato and spinach aphids. The disease appears on the spinach within twelve to thirty days after the feeding of the contaminated insect. Some infections are obtained even though the aphids remain on the plants for only five minutes. The insects are able also to inoculate five or more plants in succession after feeding once on diseased foliage. Molting of the aphid does not remove the contamination from its body. Furthermore, the virus may be transmitted from parent aphid to offspring for four or more generations.

The virus of yellows that affects other plants overwinters in the root sap of living perennial plants. This has not been proved true for spinach yellows. In the Southern States the aphids are capable of retaining the virus from one spinach crop until the next.

Control

In localities where yellows is general the only means of combating the trouble is the procuring of resistant spinach varieties. A cross was made between the Manchuria and the Savoy, and the new variety, which has proved resistant, is named *Virginia Savoy*. Another strain obtained later is known as *Old Dominion*. These should be planted instead of other types if the disease has caused much loss. Spraying or seed treatment is of no value as a direct control measure. Eradicating the aphis is helpful because it destroys the virus carrier.

MALNUTRITION

(Caused by unfavorable environmental conditions)

The spinach plant affected with malnutrition is dwarfed, and the foliage has yellowed tips and edges. The symptoms of malnutrition are somewhat like those of yellows or mosaic, but the disease may be distinguished by the following characteristics: The diseased leaves do not exhibit the normal savoyed effect of healthy leaves but are unusually thick, and the tissue is very brittle. The petioles and basal portion of the leaf show a marked red discoloration. In severe cases the whole leaf turns red. The plant dies prematurely.

Control

The control of malnutrition consists in liming the soil if it is too acid, or using an acid-producing fertilizer if it is too alkaline, and in applying a reasonable amount of a complete, well-balanced fertilizer. The soil, too, should be well supplied with humus and should otherwise be in good tilth.

LETTUCE AND ESCAROLE

Lettuce and escarole diseases are very destructive, sometimes taking more than half of the crop. Unfortunately only general control measures are available. These include the removal of lettuce refuse, crop rotations, dusting, and eradication of weeds in the vicinity of the field.

BOTTOM-ROT

(Caused by *Rhizoctonia solani*)

Bottom-rot is by far the most destructive rot of lettuce in this State. The rot starts where the bottom leaves rest on the ground, and generally works up into the head, destroying first the blades of the leaves and less rapidly the midribs, but never rotting off the main stem of the plant. It is caused by the very common and widespread fungus known as *Rhizoctonia*, which attacks the plants from the soil, and which is very destructive when the lettuce leaves and the supporting soil remain moist. The parasite lives in the soil, on growing plants, and on diseased plant refuse. Its greatest

period of development is after the healthy plants have been harvested and those with infection have been left to rot in the field.

Control

An important practice is long rotations with such crops as sweet corn, tomatoes, potatoes, cucumbers, radishes, beets, onions, and spinach. If a field becomes heavily infested with bottom-rot, it may be advisable to plant some cereal or hay crop for a year or two.

All vegetable crops, particularly celery, carrots, and cabbage, should be harvested promptly and removed from the field so that no molds can reproduce on them. As soon as the lettuce crop is harvested, all the unused plants or other lettuce refuse should be hauled a considerable distance from the field and placed in a composting heap. Even though this entails much labor, it has proved very profitable, since the fungi multiply rapidly on the old plants left in the field.

The moisture can be controlled somewhat by planting in well-drained soil, which receives frequent shallow cultivations, and by eradicating the weeds in the field and along the ditch banks so that there can be good aeration.

Excellent results have been obtained by the use of dust for the control of bottom-rot. A specific organic-mercury dust (No. 738) is blown under the plants by means of a special lettuce duster. One application of 25 to 30 pounds of the material is sufficient if made two or three weeks before the crop is harvested.

In greenhouses, the bottom-rot can be controlled by soil sterilization.

DROP

(Caused by *Sclerotinia* spp.)

The lettuce drop is mostly a greenhouse, hotbed, and cold-frame trouble, although it may be found also rather commonly in some fields, especially on escarole. The rot begins on the stem near the surface of the soil, and rapidly spreads upward, killing the leaves in succession, until it reaches the heart of the plant. The dead tissue changes to a wet, slimy, decayed mass. The white fungus may grow over the entire plant, and also form many black, variously shaped sclerotia, which are the resting bodies. The parasite remains alive in the soil for a long time, and reproduces rapidly in the lettuce refuse left in the field or in the beds where it is grown. The same fungus attacks nearly all other kinds of vegetables, especially carrots, cabbage, and celery.

Control

The recommendations for the control of drop are similar to those for bottom-rot (page 40). Dusting as yet has proved only partly successful.

TIPBURN

(Caused by unfavorable weather conditions)

Tipburn is one of the most destructive injuries with which lettuce growers have to contend. It is not severe on the early spring crop nor on the late fall one, but during the summer it may destroy the salability of nearly every plant in the field. On affected lettuce the edges of the leaves die and turn brown, in severe cases interfering with growth.

In a general way tipburn is known to be caused by weather conditions, chief of which is high temperatures, but the exact combination of conditions is still being debated. Formerly it was considered that the hot sun shining on the succulent, fast-growing tissue caused the injury, but it is now considered that the tipburn can originate even in the dark. It probably is a degeneration of the cells due to faulty respiration, which is brought about by high temperature.

Control

No definite control measures are known. A few precautions may help in reducing the loss in a crop. Deep and frequent cultivations when the soil is packed by heavy rains, sparing use of potash, and medium applications of superphosphate have reduced the amount of tipburn in certain fields. The Big Boston head lettuce is very susceptible, and it might be possible to substitute some other variety for the midsummer crop.

YELLOWS

(Caused by a virus)

Lettuce yellows is known also as *white heart*, because the center leaves become bleached and dwarfed. The head does not form even though the plant may continue to live. Young infected plants usually die. Old plants are not much injured by infection. The same disease is found on escarole, other cultivated crops, and many weeds. It is carried only by the leaf hoppers from one plant to another, and gradually is becoming one of the most important diseases of lettuce, asters, and other hosts.

Control

No control measures are known. If all the weed hosts for half a mile or more could be eradicated, the disease might disappear. Plants protected by a cheesecloth covering will remain healthy, but the expense of such a control measure is too high to be practicable.

MOSAIC

(Caused by a virus)

In mosaic, the lettuce leaves become mottled with yellow and green, ruffled, or otherwise distorted and dwarfed. The whole plant has a sickly

appearance, and in most cases will not bear a head. The virus is carried in the seed and is transmitted by aphids and other sucking insects.

If disease-free seed could be obtained, mosaic could readily be controlled, but this has not yet been found possible.

DOWNY-MILDEW

(Caused by *Bremia lactucae*)

Downy-mildew is injurious mostly in the greenhouse or in coldframes when proper ventilation is not possible. The spots begin as lighter green areas on the upper surface of the leaves, and, as the lesions enlarge, the fungus fruits with white mycelium wefts in corresponding spots on the opposite side. The affected tissue later turns brown. The whole plant may be dwarfed and yellow. The fungus is supposed to overwinter on wild lettuce. It requires a large amount of moisture for growth as well as cold nights and relatively warm days.

Control

The control consists mostly in correcting conditions favorable for the fungus. In coldframes where the temperature often is rather low, the air must be kept comparatively dry or the mildew is sure to spread. There should be some ventilation both day and night, to avoid high humidity. Each year the sashes should be inspected carefully, all broken panes replaced, and others thoroughly calked. In greenhouses, if the night temperatures can be raised three or four degrees above normal for lettuce growing, the fungus will not thrive.

GRAY MOLD-ROT

(Caused by *Botrytis* sp.)

Gray mold-rot is of little importance outdoors, but is destructive occasionally under glass. Rotted plants are covered with a dirty gray, fuzzy mold. The disease attacks weak plants mainly, and in some measure can be avoided by obtaining a strong vigorous growth. In hotbeds and coldframes, special care should be taken to provide ventilation, so that drops of moisture will not collect on the inner side of the glass and drip back on the plants, for such moisture provides an excellent environment for the growth of the fungus. In greenhouses, if the night temperatures are lowered as far as is possible without injury to lettuce, the rot can be much reduced.

CUCURBITS

A seasonal system for the control of insects and diseases injurious to cucurbits begins with seed treatment for the leaf-spots and scab, followed by early dust treatments for the cucumber beetle. After these treatments, a regular schedule of spraying or dusting should be followed to control the beetles and the various vine and leaf diseases.

ANGULAR LEAF-SPOT

(Caused by *Bacterium lachrymans*)

Angular leaf-spot is very common and sometimes destructive in most of the older cucumber-growing districts. It affects cucumbers, certain gourds, and a few less-known plants of the same family.

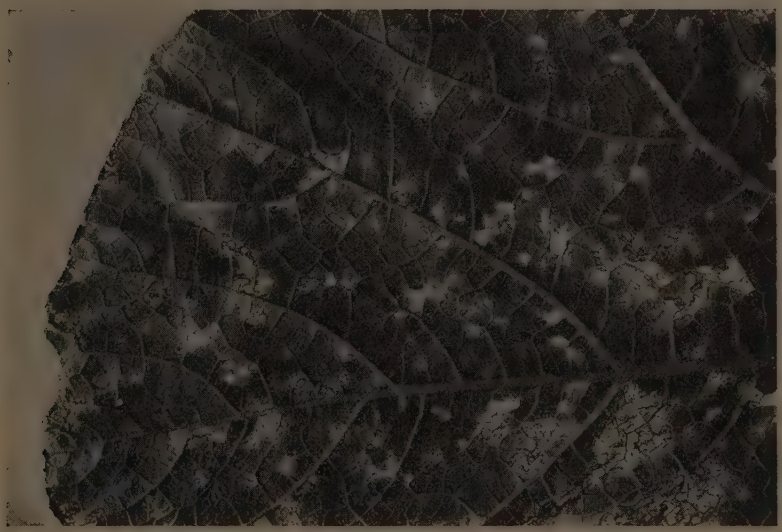

FIGURE 5. ANGULAR LEAF-SPOT ON A CUCUMBER LEAF

The disease appears on the leaves, the stems, and the fruit. The spots on the foliage are irregular in shape, angular, and have a water-soaked appearance. In the presence of moisture, bacteria ooze from the spot in tear-like droplets, which dry down into a white residue. The water-soaked area later turns gray and dies. The drying and shrinking of the dead tissue may tear it away from the healthy portion, leaving large irregular holes in the affected leaves. The spots on the fruit are much smaller and nearly circular. When the diseased portion dies, the tissue becomes white in color and may crack open.

The bacterium causing the disease overwinters in diseased plant refuse and on the seed. During rains it is splashed from the soil to the stems and the leaves, and later to the fruit. After infection has once taken place, the organism is transferred readily on the hands and the clothing of the pickers. Infection takes place through the stomata, and, since they close during the night, most of the entrances by the bacteria take place in the early morning after daylight but before the dew or the rain has evaporated. Inoculation

may take place on the fruit just before picking. If such cucumbers are shipped long distances, much spotting may appear during transportation on fruit that apparently was healthy when picked. Frequent rains and a temperature of 75° F. are optimum conditions for the growth of the bacterium.

Control

The control methods are the same as those recommended for the control of cucurbit scab (page 45).

ANTHRACNOSE

(Caused by *Colletotrichum lagenarium* (Pass.) E. et H.)

Anthracnose is almost always present on watermelons, and to a lesser extent affects also muskmelons, gourds, and cucumbers. Squash and pumpkin are almost immune. The fungus produces angular black spots on the leaves and elongated black spots with light-colored centers on the petioles. The small fruits are sometimes killed, after which they turn black and drop off. The older fruits have dark bordered cankers with flesh-colored ooze in the center. Soft rots may follow these depressed cavities.

The fungus lives over winter in diseased melon and cucumber refuse, as well as in and on the seed. When contaminated seed is planted or old vines are present, the fungus is splashed to the new plants where it may become destructive when weather conditions are favorable. The fungus requires a fairly high temperature and plenty of moisture for most rapid growth.

Control

The control methods are similar to those recommended for the control of cucurbit scab (page 45) except that seed treatment will not kill the fungous threads that have grown into the seed.

SCAB

(Caused by *Cladosporium cucumerinum*)

Scab occurs on cucumbers, muskmelons, and pumpkins. The affected leaves have water-soaked spots and become wilted. The stems also have slight cankers, but most of the injury occurs on the fruit, where at first there is an oozing of sap, as if there had been an insect sting. Later the spot increases in size and becomes a sunken cavity lined with an olive-green mold. The fruit finally may be destroyed by a soft rot.

The scab is caused by a fungus that lives over in old cucumber refuse, in the cracks about the greenhouse, and on the seed. It develops best in moist air with a temperature of about 77° F.

FIGURE 6. CANKERS ON CUCUMBER FRUIT CAUSED BY SCAB

Control

A few helpful suggestions include long crop rotations and plowing under diseased vines immediately after harvest. But the two important recommendations are seed treatment and spraying or dusting. The cucumber or the other cucurbit seed are tied loosely in a cheesecloth bag and are dipped in a corrosive-sublimate solution (1–1000) for five minutes. They are then rinsed in clean water and dried, or they may be planted while still wet. The corrosive-sublimate solution is made by dissolving 1 tablet in each pint of water required; or by dissolving 1 ounce of the powder in a little hot water and then adding enough cold water to make 7½ gallons. This should always be made up in wooden, glass, or earthenware containers, and never in metal ware.

The spraying on cucumbers is done with bordeaux mixture, 3–3–50, to which is added 2 pounds of calcium arsenate. Muskmelons are susceptible to injury, so the strength of the bordeaux mixture is reduced to 2–2–50. The ordinary copper-arsenate-lime dust 15–15–70 may be applied both to the cucumbers and the melons.

While the plants are small, a hand sprayer or duster may be more desirable than a horse-drawn machine, for, when the plants are far apart, much of the material is wasted on the ground between the hills. When the vines are large, a horse-drawn machine is preferable, for then it is necessary to

direct from three to six nozzles toward each row. The discs in the sprayer nozzles should have small openings so that the spray will be forced out as a fine mist. The dust nozzles, too, must be arranged in such a manner that every part of the plant will be covered.

Because of possible injury to plants from the copper fungicides, each grower should determine how early in the life of the young plants he can safely apply bordeaux mixture or copper-lime dust without danger of stunting the plants and then make the applications as soon as he feels it is safe. If applications of a fungicide are not made until late, the bacterial wilt will not be controlled. Applications thus are made at weekly intervals, beginning after several applications of an insecticide alone have been made, and continued, at least, until the first picking. If the crop is clean, then further spray or dusting is unnecessary. If, however, later applications are made, the material should be put on directly after the picking, so the fruit will not be spotted too much. The dust is applied when the vines are wet with dew. Vines are injured by much trampling, so care should be taken when spraying or dusting.

LEAF-SPOT

(Caused by *Macrosporium cucumerinum*)

The leaf-spots on cucurbits at first are small, circular, and somewhat water-soaked. They enlarge rapidly, and may be recognized easily by the concentric rings and a definite margin on the upper side of the leaf. When enough spots are present, the foliage dies. The fungus lives over in the old plant refuse, and during the summer is splashed by rains or carried by tools from one plant to another. It may possibly be carried in the seed, though this has not been proved.

Control

The same control measures are suggested as for cucurbit scab (page 45).

STRIPED CUCUMBER BEETLE

(*Diabrotica vittata* Fabricius)

The striped cucumber beetle is without doubt the most important insect enemy of cucumber, melon, squash, and related crops. Not only does the insect cause direct serious injury to the plants from the feeding of the adults and the larvae but indirectly it causes even greater loss by aiding in the transmission of two serious plant diseases,—wilt and mosaic.

The cucumber beetle hibernates as an adult under trash and in patches of woodland, often at some distance from the fields in which the insect bred. The beetles emerge from hibernation early in the spring and feed for some time on the leaves and the flowers of various wild plants. They congregate on cucurbit plants just as they are coming up. They feed on

the leaves and gnaw holes in the stems near the surface of the ground. Many plants are killed outright and others are so badly injured that they make only a sickly growth. The most serious injury is usually done before the plant acquires three or four leaves, but the beetles are present and troublesome for a month or longer in the early summer. The beetles deposit most of their eggs in crevices in the ground near the base of the plants, but some are dropped at random wherever the female happens to be. The eggs hatch in about a week, and the larvae burrow into the underground stems or into the vines where they rest on the ground. Sometimes the main stem just below the surface of the ground becomes riddled with the burrows of the larvae, and the plant becomes seriously weakened or even killed. The larvae become full-grown in about a month, and the new crop of beetles appears in August or September.

Control

In garden plots and small plantings it is often practicable to protect plants by covering them with some kind of screen, but under commercial conditions the best results are obtained by dusting or spraying. Poisons are used in some spray applications, but only a few beetles are actually killed; the material acts as a deterrent, however, and drives them away. Early in the season dusting is the more practical method for controlling the beetles.

The most efficient dust for general use against cucumber beetles while the plants are small consists of calcium arsenate, 1 pound, and gypsum, 15 pounds. While gypsum is preferable it is too heavy to flow well in power dusters, and hydrated lime may be substituted. Dust applications can be made cheaply and effectively by means of a hand duster. The material should be distributed thinly and uniformly on the plants, since accumulations of the dust may cause leaf injury. The whole field should be treated in one day, for most of the beetles are not killed but are merely driven away from the plants. If only part of the field is dusted, the beetles will congregate in the area untreated. One hand duster will cover about 2 acres a day. The success of the treatment will depend on the uniformity and the thoroughness with which the leaves and the stems are covered with the dust. The first treatment with dust should be made as soon as the plants are up, and repeated at weekly intervals until the plants begin to run. After this the vines should be treated as indicated on page 45.

TWELVE-SPOTTED CUCUMBER BEETLE

(*Diabrotica duodecimpunctata* Fabricius)

Closely related to the striped cucumber beetle is another species, yellowish green in color, with twelve black spots arranged in three transverse

rows across the wing covers. The twelve-spotted cucumber beetle is usually not so abundant as the striped beetle early in the season and does not cause much, if any, injury by feeding on the seedling plants. It is of great importance, however, as a carrier of the wilt organism and mosaic virus.

Control

The spraying and dusting schedule indicated on page 45 will help to reduce the number of beetles and will lessen the injury.

MELON APHIS

(*Aphis gossypii* Glover)

While several species of plant lice occasionally attack cucurbits, the greater part of the injury in New York is caused by the melon aphis. This insect is known by a number of names, including *cucumber aphis*, *cantaloupe aphis*, and *cotton aphis*. When attacking greenhouse plants, it is called the *black-fly*.

The melon aphis passes the winter, in the northern part of its range at least, in the egg stage on orpine, or live-forever. The lice develop on this plant early in the spring and then, when winged forms are produced, migrate to cucumber and melon. The time at which cucurbits are attacked varies considerably, but in New York it is usually rather late in the season. The lice congregate on the underside of the leaves, causing the leaves to curl downward, turn brown, and die. In severe infestations the vines may be killed or so injured that the crop is small and of inferior quality. Furthermore, the lice are instrumental in spreading certain plant diseases from plant toplant.

Control

The melon aphis is readily killed by spraying with nicotine sulfate, ¾ pint in 100 gallons of water in which 4 or 5 pounds of soap has been dissolved. To be effective, however, the spray must be applied so as to hit the underside of the leaves where the lice are most numerous. This is a rather difficult thing to do under commercial conditions. It is more practical and less expensive to use a 2- or 3-per-cent-nicotine-lime dust. The treatment should be made on a hot quiet day, and care taken to envelop the plant with a cloud of dust, especially close to the ground.

BACTERIAL WILT

(Caused by *Bacillus tracheiphilus*)

The bacterial wilt is one of the more serious troubles of cucumbers, squashes, muskmelons, and pumpkins in the States east of Kansas and north of Tennessee. It rarely causes the loss of all the crop, but a loss of 10 to 20 per cent of the vines is not uncommon.

The disease starts on a single leaf, which gradually wilts and dies. The wilting spreads to the vine and finally to the whole plant. In certain squashes that are rather resistant there is no true wilting but a distinct dwarfing of the vine. Aside from wilting and dying or dwarfing there are no other typical outward symptoms. If, however, the affected stem is cut crosswise and some of the plant juice pressed against the finger, the juice will string out if the finger is withdrawn slowly. The sap of the healthy plant is watery and will not string. Drops of bacterial ooze may collect on the surface of the fruit. The roots are not affected directly.

The disease is caused by a bacillus that can overwinter only in the digestive tracts of the striped and the twelve-spotted cucumber beetles. In the spring the parasite is deposited on the cucurbit leaves in the droppings of the beetles. It enters the host tissue through feeding wounds or directly through breathing pores, enters the sap ducts, and finally migrates to all parts of the vine. It is disseminated to other plants by insects and pickers.

The weather conditions seem to have very little to do directly with the increase or the decrease of the disease. Any environment that favors the feeding of the beetles, such as moderately high temperature, naturally has a great effect on the number of infections later.

Control

A few plants in the garden may be protected by inclosing them in cheesecloth tents. Specially prepared sticks or wooden barrel hoops cut in halves are placed at right angles to each other, and their sharpened ends are inserted in the ground. The cheesecloth is stretched over the hoops and its lower edges are weighted with stones or soil so that no insect can crawl under the covering. Large plantings of cucurbits must be protected by insecticides and fungicides. The same dust or spray schedule is required as that suggested for the control of cucurbit beetles (page 47) and of scab (page 45). In the application of a fungicide it must be remembered that infection takes place when the plants are very small, so that the spraying or dusting to be effective must be begun soon after the first true leaves appear. Each grower must determine how early in the life of the plant a fungicide can be applied without stunting the plant seriously.

It has been found that the American varieties, such as Chicago Pickling, and other related pickling strains are much less susceptible than are similar varieties originating in Europe, such as Half Long Prolific, Oblong Green Pickling, King William, Short Green Parisian, and others. Where wilt has been severe, the American varieties should be chosen even though they are far from immune.

MOSAIC

(Caused by a virus)

Mosaic is one of the most threatening of all the diseases found on cucumbers and muskmelons. In some of the older sections the growing of these crops has become unprofitable, and the disease seems to be increasing in all the newer areas. If all growers do not take every precaution to eradicate the virus, the cucumber crop in New York State is almost sure to be much diminished unless resistant varieties can be found.

At least two distinct mosaics occur on cucurbits, although only one of them seems to be of a very virulent nature.

Slightly affected vines of cucumbers, muskmelons, and squash show the normal green of the leaf to be mottled with light yellow areas. The fruit, too, may be mottled, or have a much roughened surface caused by knobs of green, developing normally while the tissue between fails to grow. Sometimes the green color is almost totally lacking, and the disease then is known on cucumbers as *white pickle*. In severe cases the plants are yellow and very much dwarfed. Such plants bear little or no fruit.

The mosaic disease is caused by a virus in the sap of the affected plants. It lives overwinter in the seed of the wild or bur cucumber and in the roots of perennial plants, such as milkweed, catnip, poke-berry, ground cherry, or husk tomato. When these plants come up in the early spring, the cucumber aphis, the striped cucumber beetle, and the twelve-spotted beetle feed upon them. The mouth parts of the insects become contaminated with the virus which they carry to cucumber, muskmelon, squash, or pumpkin plants. Within five to ten days the new infections begin to show. The disease may then be transmitted from plant to plant in the field by insects or on the hands of workers harvesting the crop. It apparently is never carried in the seed, and does not overwinter in the soil.

Control

In order to avoid the weed hosts that carry mosaic, the cucumber or melon field should be surrounded by cultivated crops and should not be near buildings, grainfields, hedge rows, vacant lots, or other places where the susceptible weeds grow undisturbed. The host plants—wild cucumber, ground cherry, pokeweed, milkweed, catnip, and possibly still other weeds on Long Island, that grow in the cucurbit field or within 50 yards of its outer edge should be pulled up and destroyed. The field should be inspected for these weeds even before the cucumbers or the melons are planted, and the inspections repeated at frequent intervals during the growing season until there is no more danger from infection. This is not an easy task, but it is the only remedy until resistant varieties are found. It would be a great help in weed eradication if the location of the cucumber or melon

field were planned the fall before spring planting; for as soon as cold weather began crystals of some weed killer, as sodium chlorate, could be sprinkled along the fence rows or other places where clumps of the carrier weeds are known to occur.

If infected plants are found in the crop early in the season, it may be well to pull them up at once and remove them from the field. It is doubtful, however, if this roguing is of any value after the plants become nearly grown. Only that part of the plant which develops after inoculation takes place is injured much by the disease, so that if all early infections are avoided, the crop loss can be much reduced.

Seed treatment and spraying or dusting are of little or no value in mosaic control, except in so far as insect feeding is hindered.

Work is now under way in several States in developing resistant strains, which finally may be available.

DOWNY-MILDEW

(Caused by *Peronoplasmopara cubensis*)

The downy-mildew, or blight, may be destructive on Long Island if the weather conditions are right, but it rarely is found up-state. It affects not only cucumber, squash, pumpkin, and muskmelons, but also a number of other closely related plants.

Irregularly shaped yellowish spots appear on the upper sides of the foliage, usually on that nearest to the center of the hill. If the leaf is examined on the opposite side when dew or rain is present, the brown lesion will be covered, or at least bordered, by a purple fungous growth. The spots increase rapidly in size until the whole leaf withers and dies. In a badly diseased field it is not uncommon to find all the foliage dead near the center of the hill, with only the young leaves remaining at the tips of the vines. If fruit is being formed during the attack, it will remain dwarfed and have a poor flavor. Cucumbers so affected are known as *nubbins*. The fungus requires much moisture, accompanied by cool nights and warm days, for best development. It is not known how it lives over during the winter, nor is it known to be carried in the seed.

Control

Long rotations and plowing under diseased vines immediately after harvest are usually recommended as precautionary methods. The principal control measure, however, is repeated and thorough applications of bordeaux mixture or copper-lime dust. The spray or dust schedule for the control of downy-mildew on cucurbits is the same as that outlined for the control of cucurbit scab (page 45).

SQUASH BUG

(*Anasa tristis* De Geer)

The adult squash bug is about 5/8 inch in length, and is dirty brownish black in color above and brown, mottled with black, below. The adults hibernate in dry sheltered places and emerge in the spring to attack cucurbit plants as soon as they come up. The female deposits her rather large, brownish eggs in regularly arranged patches on the underside of a leaf. The eggs hatch in from six to fifteen days. When first hatched, the young bug is brightly colored; but, after the first molt, it becomes light dusty gray in color, almost white. The nymphs feed in colonies on the underside of the leaves, causing the leaves to wilt, curl up, turn brown, and die.

Control

While the squash bug is a serious and troublesome pest in the garden, it fortunately causes little injury in commercial plantings. In the garden, the following methods will be found of value in preventing injury. The number of bugs appearing on the plants in the spring can be greatly decreased by practicing clean farming and thus reducing the available shelter for the hibernating insects. After the crop has been harvested, the vines should be raked up and burned or converted to compost. This will prevent many of the later hatched nymphs from reaching maturity. The use of proper fertilizers and thorough cultivation will often enable the vines to withstand attack and outgrow the injury. After the ground has been fitted, but before the plants are up, many of the bugs can be trapped under pieces of boards placed on the ground. They collect under such shelter during the night. The boards should be examined every morning and the insects killed by hand. It will pay also to keep watch of the plants for some time after they come up. Whenever colonies of the young bugs are discovered, they may be destroyed by a thorough application of a pyrethrum dust containing ½ of 1 per cent of pyrethrins.

SQUASH VINE-BORER

(*Melittia satyriniformis* Hübner)

One of the most troublesome insect enemies of squash and pumpkins is the squash vine-borer. The insect also attacks cucumbers and melons, but so far commercial cucumber plantings on Long Island have escaped noticeable injury. The borer is the larva of a day-flying moth which, when on the wing, is easily mistaken for a wasp. The moth deposits her eggs on the stem of the plant, and the young borer penetrates the vine and burrows through the stem, usually towards the base. The burrows of the larger larvae are usually wet, slimy, and partly filled with excrement; decay often

ensues and hastens the death of the vine. When mature, the borer leaves the stem and enters the ground an inch or two for pupation. On Long Island there is one brood and a partial second, while farther north there is only one generation a year.

Control

No really satisfactory method of controlling the squash vine-borer has been devised. It may be held in check, however, by practicing such of the following methods as are warranted by the severity of the outbreak and by other local conditions. Since the insect passes the winter in the ground, it is not a good policy to grow squashes in the same field year after year. If for any reason it is necessary to raise successive crops of squashes on the same ground, the land should be harrowed in the fall, to expose the cocoons, and then plowed deeply the following spring. The vines should always be collected and destroyed as soon as the crop is harvested, in order to prevent the late caterpillars from reaching maturity. If all the growers in a locality would cooperate in the early destruction of the vines, the number of moths that would normally appear the following spring would be greatly reduced. Sometimes much injury may be avoided by late planting and heavy fertilization to promote rapid and heavy growth. In some localities the use of early squashes as a trap crop has been attended with success. A few early squashes, such as crooknecks, are planted early around the field and between the rows of the late varieties. The moths will deposit their eggs on the early squashes, and the main crop, coming up later, will escape the greater part of the infestation. As soon as the early squashes are harvested, or sooner if they crowd the main crop, the vines should be pulled up and burned or composted, in order to kill the borers they contain. After the borer has once entered the vine, there is nothing to be done but to cut it out with a knife. If care is taken to make the cut lengthwise of the stem and if the vine is immediately covered with earth at the injured point, the wound soon heals and the vine continues its growth. Some growers make a practice of covering the stem with earth 2 or 3 feet from the base, in order to make the vine throw out a new root system which will sustain the plant in case the main stem is injured at the base.

Experiments have indicated that nicotine sulfate is effective in killing the eggs. To be effective, however, 1 quart of nicotine in 25 gallons of water must be used. Four treatments should be made at weekly intervals. Only the basal 4 feet of the vine need be sprayed. This is an expensive treatment and should be used only when the value of the crop would justify the outlay.

POWDERY MILDEW

(Caused by *Erysiphe cichoracearum*)

The powdery mildew affects melons, cucumbers, squashes, pumpkins, and nearly every other kind of cucurbit, as well as some unrelated plants.

The fungus appears as a white mealy growth on the upper side of the leaves. When the fungus grows luxuriantly, the foliage withers and dies. It is not known definitely how the mildew lives over the winter, or whether it can be disseminated with the seed. Its growth is favored by high temperatures and absence of dashing rains.

Control

The usually suggested means of control is to spray the plants as suggested for the control of scab (page 45). Seemingly only the wet form of the copper fungicide is effective. Sulfur is more toxic to the powdery-mildew fungus than is copper, but is not recommended because of its injury to the plants. In Ohio, however, some experiments have been conducted with a new form of sulfur known as hydrophilic colloidal sulfur, 2 pounds of the paste to 100 gallons of water, with apparent success and no injury to the crop. This has not been tried under Long Island conditions. In the Imperial Valley of California, resistant melons have been bred that are suitable for their climate. It is doubtful whether the same melons would be of value for Long Island growers.

ONION

ONION MAGGOT

(*Hylemyia antiqua* Meigen)

While present throughout the State, the onion maggot is most destructive on the muck soils of western New York. Here a large acreage of onions is grown year after year on the same land, and the insect is able to maintain itself in excessive abundance.

The adult of the onion maggot is an ash-gray fly about 1/5 inch in length and closely resembles the adults of the cabbage root-maggot and of the seed corn maggot.

The onion maggot winters in the puparium stage in the soil of onion fields or under piles of onion refuse and cull onions that were discarded at harvest. In New York the flies begin to emerge about the middle of May and continue to appear for about a month. Flies coming from refuse piles begin somewhat earlier than in the open field and emergence continues for a longer period. Not only are refuse piles dangerous centers of infestation because of the large number of flies that they produce but also because they materially lengthen the period during which the flies emerge.

The flies do not begin egg-laying as soon as they emerge but wait from one to three weeks before the first eggs are deposited. This is known as the *pre-oviposition period* and averages about 10 days in length. The flies deposit their smooth, white, elongate eggs in crevices in the soil around the

plants or in the axils of the leaves at the base of the plant. The eggs hatch in from two days to a week, depending on the temperature. The feeding habits of the maggots vary somewhat with the size of the plants attacked. In young plants the maggots are to be found both in the bulb and in the stem aboveground. The bulb is often completely hollowed out, leaving only the outer sheath intact. The maggot requires from fifteen to twenty days to reach maturity. It then leaves the onion and burrows a short distance into the surrounding soil, where it transforms into a pupa within the hardened larval skin, or puparium. The puparium is chestnut brown in color and about 1/5 inch in length.

A second brood of flies emerges during July and early August, the greater number appearing during the last half of July. Usually a small partial third brood of flies appears late in the season. Sometimes newly hatched larvae of the last brood have just entered the bulbs at harvest time. These may develop in storage, causing serious loss.

Control

The most practical method of controlling the onion maggot under Long Island conditions is by treating the seed with calomel. Equal weights of onion seed and calomel are used. The seed is first placed in a cheesecloth bag and dipped in a pail of water for a moment to moisten the seed-coat. The damp seed is then placed on a flat smooth surface and the calomel powder added. The two are then thoroughly mixed by hand until all the calomel adheres to the seed. The seed should be just moist enough to cause the calomel to adhere to it; if the seed is too wet, a pasty mass will result. It is best to have a deficiency of water at the start and to add more as needed. Treated seed should run freely when taken up and pressed in the palm of the hand.

The treated seed should be sown as soon as possible after mixing. If left too long, part of the calomel will flake off the seed, thus decreasing the effectiveness of the treatment. The loose calomel may also cause the drill to clog. Since the size of seed is increased by the coating of calomel, the drill openings must be set about two sizes larger for sowing treated seed than for untreated.

ONION THRIPS

(*Thrips tabaci* Lindeman)

Onions are subject to injury by a small yellowish or brownish thrips which punctures the epidermis of the leaves, sucks out the juices, and causes the plants to turn whitish, wilt, and fall down. While the insect causes important losses in all parts of the State, it is more destructive in southeastern New York than elsewhere. Onions grown from seed are

more severely injured by the thrips than are those grown from sets, but the latter are usually heavily infested and serve as breeding reservoirs from which the insects spread to seed onions.

The onion thrips passes the winter in both the adult and the nymphal stages on onion plants left in the field and in rubbish on the ditch banks and along the edge of the fields. The adult thrips is only about 1/25 inch in length, light yellow to brownish in color, and provided with two pairs of slender wings that are fringed with long hairs. The female inserts her minute whitish eggs into the tissue of the leaf. The eggs hatch in from a week to ten days. The nymph passes through two stages while feeding on the plants and then enters the ground, where it passes through two more immature stages before becoming adult. The life cycle is completed in about twenty-six days. There are five or six generations annually, and breeding is continuous until stopped by cold weather.

A careful examination of infested onion plants at any time during the summer will disclose the presence of four stages of the onion thrips; namely, egg, first- and second-stage nymph, and adult. Both the nymphs and the adults feed on all parts of the leaves but are to be found in large numbers hidden under the sheath at the base of the leaves or between the young leaves at the center of the plant. In feeding, the thrips punctures the epidermis of the leaf with its sharp, needle-like mouth parts and then sucks out the juices of the plant, killing the cells and causing them to turn whitish. When the infestation is severe, the leaves assume a dirty white or bleached appearance. Badly injured plants wilt, and the leaves fall over on the ground; the bulbs do not make the proper growth, and the crop is of small size and inferior in quality. The plants are most susceptible to injury during July and August when they are making their most rapid growth. The thrips is most destructive in years of drought and on onions grown on poor or poorly cultivated soil.

Control

Set onions should never be grown near seed onions because they may be an important source of infestation for the latter. The thrips get an early start on the sets and are very abundant on them when they mature and are pulled. They then migrate in great numbers to the seed onions and augment the injury caused by the thrips already present. The farther set onions are grown from seed onions, the better.

DOWNY-MILDEW

(Caused by *Peronospora schleideni*)

Onion mildew is common in the State, and during wet, cool weather may become very destructive.

It seldom occurs early in the growing period of the plant; the first symp-

toms on the leaves are ordinarily not discernible until the bulbs begin to form. The infection starts on one or a few isolated plants which serve as centers from which the inoculum is disseminated. Even before there is any discoloration of the foliage tissue, the fungus, on wet mornings or during a rain, forms a purplish mold over the surface of the leaf. As the infected spot enlarges, the whole leaf takes on a water-soaked appearance, then later turns yellow, and on drying may become white. Soon after infection takes place, the leaf, because of the weakened tissue, may drop over, shrivel, and become black with mold.

The pathogene overwinters as mycelium in the seeds, onion bulbs, and sets, and as oospores in the old diseased foliage. If infected seeds, sets, or large bulbs for seed are planted, the mycelium grows up with the foliage, and, when favorable weather conditions prevail, the fungus fruits.

The parasite, being a downy-mildew, requires plenty of moisture with rather cool nights and relatively warm days. When such a combination of weather occurs, an epidemic may be expected wherever the fungus is present.

Control

Since the parasite lives in the old onion refuse, a rotation of crops extending over three or four years is the first recommendation. The second is to plant in well-drained soil and where there are no wind barriers, as woods, hills, and weeds, and where there is nothing to prevent the tops of the plants from drying during the day. The third is to burn diseased-onion refuse. The fourth recommendation is to obtain disease-free seeds, sets, or seed bulbs. This may not be possible at present, but if greater care is taken in growing sets, and especially if each consumer knows the source of his seeds and sets or grows them himself, he may be able to obtain disease-free stock.

Sometimes it is possible to select varieties that have small tops, which dry quickly and do not mildew so severely as do those with large tops. As an instance of this, the small-topped Mountain Globe Danvers do not blight so badly as do the large-topped South Port Yellows.

Much has been written regarding the spraying of onions. At best, it is a difficult task, and only under certain conditions is it profitable.

NECK-ROT

(Caused by *Botrytis allii* and others)

Neck-rot is known to be serious on mature onions and on sets, and probably is present in every part of the world where onions are stored. In poor storage places the loss may comprise the total crop. In some years the fungus also causes blasting of the onion flowers or injures the viability of the seed.

Neck-rot is confined to varieties of the common onion. The white onion is much more susceptible than is either the yellow or the red type. The onion with a thin neck, which dries easily, is less susceptible than is another of the same variety that is thick-necked.

The disease seldom occurs on the bulbs while they are in the ground, although the fungus may attack injured leaves even when the plants are young. The lesions on the bulb appear as sunken dried-out places about the neck, which finally may involve the whole bulb. In a cross-section the scales appear as if they had been cooked. The tissue is soft and of a brownish color. Between the scales is a gray mass of mycelium, and on the dried parts of the scales small black sclerotia begin to form. On the outside, particularly about the neck, the sclerotia may form in a solid crust. Onions that do or do not have superficial sclerotia often have part of their surface covered with the characteristic ashen-gray fruit-layer of the parasite. The roots may be included also in the decayed area, especially if the bulb is attacked at its base. Occasionally soft-rot bacteria follow the neck-rot, causing the onion to become soft, watery, and foul smelling. The neck-rot, when unaccompanied, results in a dry-rot.

Infection takes place through wounds at the neck of the bulbs during or following harvest, the invaded area continuing to enlarge while the onions are curing and after they are housed. The fungus seldom passes from bulb to bulb in storage unless the adjoining tissue is exposed by open wounds.

The Botrytis survives the winter by means of the sclerotia and as mycelium in the decaying host. The spores are blown by wind or carried on tools and clothing to the flower head, the leaf sheaths, the inner dry scales, and at harvest time to the cut tops and roots.

Control

If the fact is kept in mind that well-dried, well-stored onions are seldom affected, protection will seem fairly simple. First, the onions should be so grown that they will mature readily. Late applications of fertilizers and the presence of downy-mildew, weeds, and wind barriers should be avoided. At harvest the tops should be cut very close, and every attempt made to dry the stubs before placing the crop in storage. It has been shown that mature bulbs or sets may be dried artificially to good advantage. They are placed in shallow trays and held at 90° to 120° F. for from forty-eight to seventy-two hours. In addition, all thick-necked bulbs, or scallions, are removed as their slow drying qualities cause them to succumb quickly to the disease.

The onions should be stored in slatted crates, which are so piled that air can circulate all about them. The temperature should be kept as nearly 32° F. as possible, and the humidity of the air as low as the arrange-

ment of the room will permit. A steeply pitched roof with ventilators at the peak will aid in removing the warm moist air. If the doors are then kept tightly closed on damp misty days and opened only when the air is cool and dry, the amount of shrinkage from rot in an onion crop can be much reduced.

SUN SCALD OF ONIONS AND LEEKS

If onions and related crops are grown in such a manner that the bulbs extend above the surface of the soil or if they are harvested and the bulbs are left lying for a half day or more in the hot sun, sunscald is likely to occur. The tissues on one side of the plant take on a scalded appearance, and the color, if present, takes on a paler and duller shade. Black mold, or soft-rot, frequently follows the injury and destroys the bulb.

Control measures consist in growing and cultivating the crop so that a minimum of the bulb extends above the surface of the ground. If the crop is harvested on a bright warm day, the bulbs should be removed from the sunlight as soon as possible.

TOMATO

Among the control measures for the insects and diseases that affect tomatoes are the selection of resistant varieties, seed treatment, and spraying or dusting in the seedbed and in the field.

POTATO FLEA BEETLE

(*Epitrix cucumeris* Harris)

The small black potato flea beetle often attacks tomato plants in the seedbed and when they are first set out in the field. These beetles are only from $\frac{1}{16}$ to 1/12 inch in length. When disturbed, they jump quickly into the air and disappear from view. They are commonly known as "fleas." The beetles feed on both the upper and under surfaces of the leaves, eating out small round holes in the leaf tissue but usually leaving the epidermis on the opposite side intact. This soon dies and breaks away, leaving the foliage riddled with small holes. Badly injured leaves turn yellow or brown, curl up, and die.

Control

The two or three early applications of bordeaux mixture of the same strength as that used for the control of blight (page 61) are of great value in protecting tomato plants from flea-beetle injury.

BACTERIAL CANKER

(Caused by *Aplanobacter michiganense*)

Bacterial canker only of late years has caused any particular damage in the State. The first symptoms of the trouble are wilting, rolling, and

FIGURE 7. BACTERIAL-CANKER SPOTS ON TOMATO FRUIT

browning of the leaves on one side of the plant. This is followed by pale yellow streaks up the stem, which later may crack open. The pith may disappear or become discolored. In severe cases the whole plant dies.

The bacterial canker disease is caused by a bacterium, and may become complicated by the presence of other bacterial organisms in the diseased tissue. The causal organism inhabits, primarily, the food-conducting tissue of the plant; later, collapsing this tissue, it may extend into the pith or through cracks of the stem to the outside of the plant. It overwinters on the seed and in the old diseased plant refuse, and in the South is known to remain alive in the soil for more than a year.

Control

Little work has been done on control measures. Preliminary tests have shown that the disease may be carried with seed harvested from diseased plants. In an attempt to control or eliminate this disease, the following precautions, which are considered good practices in tomato culture, should be observed: Care should be taken to select seed from healthy plants only. Plowing and complete destruction of tomato refuse should be practiced, as the organism may overwinter in tomato refuse. It is advisable to rotate crops so that tomatoes are grown on the same area only once in three or four years. Seed should be treated with corrosive sublimate, 1–3000 (1 tablet in 3 pints of water or 1 ounce in 22 gallons of water), for five minutes, rinsed in clean water, and dried, or planted before thoroughly dry. The

disinfecting solution should be kept in wooden, glass, or glazed crockery containers, and used only once. The seed may be tied loosely in cheesecloth bags, submerged in the solution, and agitated frequently to remove air from the bags and the seed.

EARLY BLIGHT AND SEPTORIA BLIGHT

(Caused by *Macrosporium solani* and *Septoria lycopersici*)

Early blight and Septoria blight may cause much damage on the foliage of tomatoes, and the early blight may cause much rotting of the fruit. The early, or Macrosporium, blight is the same as that found on the potato, and is the cause of the leaf-spot so prevalent in New York State. It is characterized by brown spots, with concentric rings on the leaves and black-rot spots on the fruit. The Septoria blight causes small whitish spots, with minute black fungous fruit bodies on the leaf. Both cause defoliation of the plants, and for this reason may result in sunscald of the fruit later.

Both fungi are carried in the old diseased plant refuse and will remain alive in the soil at least as long as the tomato stems are not completely rotted. They are carried also on or in the seed. Related weed hosts may keep the two fungi alive for a long time in any given field.

Both parasites grow best in wet weather, and are aided in their dissemination by the splashing of rain. Both require a fairly high temperature for abundant infection. The spores of the Macrosporium will germinate best at about 80° F., while the Septoria has a range of 60° to 80° F., with the optimum at about 75° F. Therefore, in a uniformly cool season the diseases do not spread so rapidly.

Control

Aside from more detailed control measures, the following general recommendations are offered: Plowing under deeply all diseased refuse directly after harvest, three-year or longer rotations with crops not belonging to the tomato family, destruction of all weeds related to the tomato family growing in the field or within 50 feet of the field; great caution in guarding against the possibility of getting diseased refuse in the seedbed, and the procuring of seed from perfectly healthy fruit.

The most important measure, however, is to spray or dust the plants in the seedbed and for two or three weeks after they are set into the field. Bordeaux mixture, 4–4–50, or copper-lime dust, 20–20–60, is the generally accepted fungicide. In the seedbed, the spray may be put on with a hand sprayer, provided the pressure is kept as high as possible and the nozzle has a fine-holed disc. In the field, the spraying should be done with a traction or engine-driven sprayer, and the nozzles so arranged that every part of the plant is covered. On some farms this practice may necessitate the wider

spacing of the plants between the rows. A hand duster is very handy for the seedbed and can be used even in the field if the acreage is small. The applications of either spray or dust should be made at weekly intervals, beginning in the seedbed as soon as the plant has true leaves, and continuing until three or four applications have been made in the field. Late applications of a fungicide are discouraged because they tend to delay ripening, and therefore the fruit may come on a late market when the price is low, or the crop may be much injured by frost. Early tomatoes probably do not need spraying or dusting in the field. The seedbed applications, however, should not be neglected.

Some varieties are much more resistant to leaf-spot than are others. The Ponderosa, the John Baer, and the Earliana are rather susceptible, the Stone and the Norton are fairly resistant, and the Marglobe is almost immune.

Since the Septoria-blight fungus usually is not present in a cool climate, seed from as far north as possible should be procured.

TOMATO WORM

(*Phlegethontius quinquemaculata* Haworth)

Tomato foliage is sometimes attacked by large green or brown caterpillars which, when full-grown, are 3 or 4 inches in length. Owing to their large size and their voracious appetite, these caterpillars are able to consume a great quantity of leaves and may defoliate the plant. Occasionally these worms become excessively abundant on Long Island.

Whenever the worms are discovered, they should be thrown on the ground and crushed under foot. If the infestation is severe, the worms may be killed by using a dust containing ¾ of 1 per cent of rotenone. The worms are more easily killed while small, and early attention to infested areas in the field is suggested.

LEAF-MOLD

(Caused by *Cladosporium fulvum*)

Few greenhouse tomatoes escape entirely the presence of the leaf-mold fungus, but field-grown tomatoes in New York State are seldom affected. The disease begins as light yellow spots on the upper side of the leaf. On the corresponding lower side greenish or purple mold soon appears. Finally the leaf tissue dies and the leaf curls up and drops. The mold is seldom found on the stem, and is difficult to detect on the fruit.

The disease is caused by a fungus that lives over in the seed and in the old diseased plant parts that are not destroyed at the end of the season. The parasite is splashed from plant to plant during the watering, and may also be carried by insects. The mold is very sensitive to dryness and this

in turn is determined largely by the light and the temperature in the greenhouse. The fungus grows best at 65° to 70° F. when the soil or the air contains much water. Consequently the disease is present in greatest abundance where the greenhouse is not well ventilated, or in the field during a wet, warm season.

Control

Since the leaf-mold must depend for growth on almost a completely saturated air, the principal control measure is the proper manipulation of the greenhouse to keep the humidity too low for growth of the fungus. Some of the steps in obtaining this condition are: wetting the plants as little as possible when watering, keeping the ventilators open even if extra coal is required for heating the house, letting in all the sunshine available, and planting the vines far enough apart so that air can circulate among them.

In some houses it has been found profitable to install fans of various types to move the otherwise stagnant air. The dry, warm air is drawn into the house and the water-laden air is expelled. This movement takes care of the immense amount of water given off by large tomato plants, for air moving at only one-half mile an hour has twice the evaporating possibilities of still air. In addition, it eliminates air pockets which are present even though the ventilators are wide open.

If no fans are available, fairly satisfactory results can be obtained by having continuous ventilator openings both at the top of the house and along both sides near the ground. If the plants are set in rows crosswise of the house so the air currents can follow down the row, the exchange of air will progress rapidly. This can be facilitated also by planting two rows closer together and the next two rows farther apart. This will permit the usual number of plants in a given space and at the same time will give the air currents wider lanes through which to move unobstructedly.

If the mold is present in cold weather, lowering the night temperature of the house to 55° F. for several nights in succession will check the growth of the parasite. This lowering of the temperature should be practiced as much as good growth of the plants will permit.

In poorly lighted and ventilated greenhouses, spraying with bordeaux mixture, 4–4–50, may be justified. It is necessary to have a power machine with high pressure in order to do effective work. The sprayer can be stationed on the outside of the house and the spray directed from a long hose. The nozzles must be equipped with fine-holed discs, and all parts of the plant sprayed at least once a week.

Some growers heat sulfur in patented sulfuretors placed at regular intervals throughout the house. The sulfur must not get hot enough to burn, for injury to the plants will then result. This sulfur fumigation should be continued for a two-hour period just before the house

is closed for the night, and repeated at weekly intervals as long as there is danger of loss from the disease.

Resistant varieties are being bred, and finally may become available to growers whose crops have suffered damage from the mold.

MOSAIC

(Caused by a virus)

The tomato mosaic is a very serious trouble in most of the older tomato-growing districts where control measures have not been followed closely. The virus causing the disease is the same as the one on tobacco and other closely related plants, not only among the cultivated crops but also among some of the very common weeds.

In the common tomato mosaic the leaves are mottled with yellow and green and their surfaces are warty. The yellow areas may die and turn brown. The affected plants are dwarfed and usually bear little fruit, although the amount of blossoming may be normal. Occasionally the fruit is affected with russeting, with streaking, or with raised blotches. Plants badly affected in the seedbed may die when set into the field. Later infection never causes death.

The cucumber mosaic on tomato allows very little of the leaf to develop except along the midrib. Therefore this disease is known as *shoe-string* or *filiform leaf*. The leaves near the top of the plant are most conspicuously affected.

The mosaic virus is carried by aphids and other sucking insects, and will live in the soil for two months or possibly longer. The common tomato mosaic virus overwinters in the roots of such hosts as ground cherries (husk tomatoes), horse-nettles, jimson weed, night-shade, bitter-sweet, matrimony vine, and other related plants. The cucumber mosaic virus lives in the roots of the additional hosts mentioned on page 50. Investigators at various times have tried to show that the virus is carried in the tomato seed, but in America this supposition has not gained general credence.

Control

The most important control measure is the eradication of the weed hosts near or in the tomato field, and especially those near the seedbed. If young plants are kept healthy, a fairly large plant may develop before the influence of the disease can reduce the yield much. In the greenhouse it is important also to avoid all tomato refuse in the seedbed, and to remove any mature, living tomato plants in the same greenhouse where young plants are being grown. Since the virus can live in the soil, the seedbed or a new crop in the greenhouse should not be planted for at least four months after the old crop has been removed.

The virus can live for a long while in natural leaf chewing tobacco, and frequently is spread to tomato seedlings when the workmen expectorate over the bed.

In greenhouses the mosaic virus is disseminated when the plants are pruned. It has been shown that the later infection is much less common if the workmen occasionally wash their hands with soap and frequently dip their pruning knives into formaldehyde (1 part in 20 parts of water). Breaking out the undesirable shoots in pruning permits less chance of contamination than does cutting.

Seed treatment and spraying have not proved effective in controlling mosaic.

STREAK

(Caused by a combination of two distinct viri)

Streak is merely another form of mosaic. It has been a common disease in greenhouses for many years, and sometimes causes losses in the field.

The trouble seldom is noticeable until the plants are fairly well grown. It infects leaves, stems, and fruit. The most prominent symptoms are the dark streaks on the stem, the spotting and sudden blighting of the upper leaves, and the dwarfing of the plant. Dead areas form in the leaves, especially along the veins, and brown streaks appear on the petioles. Light brown, sunken spots, variable in size, may be found also on the fruit. In severe cases the whole plant dies.

One kind of streak can be produced by inoculating the tomato plant with both the tomato mosaic virus and the potato virus. When the two diseases are together, they seem to be more virulent and kill at least parts of the plants. A second type is produced by a combination of tomato and cucumber mosaics on the same plant. In fact, any other host mosaic that is able to pass over to the tomato seems to cause the disease known as *streak* when it becomes mingled in the plant sap with the ordinary tomato mosaic.

Control

The control measures for streak are the same as those given for mosaic (page 64). Here again should be emphasized the destruction of weed hosts and the practice of not following tomatoes immediately after tomatoes in the greenhouse. It has been suggested that an excessive use of nitrogen in the fertilizer increases the susceptibility of the tomato plant to the disease. Therefore if streak is expected to be present, the nitrogen application should be reduced and the superphosphate and potash increased. Even when streak has begun to appear, a side dressing of these two elements sometimes helps. It seems to be of value only in certain types of streak and not in others.

POTATO LATE BLIGHT

(Caused by *Phytophthora infestans* DeB.)

A detailed discussion of the potato-late-blight fungus and its control is given in Cornell Extension Bulletin 135, "Potato Diseases and Their Control." Once in a great while as in 1932 and 1933, the same fungus attacks tomato fruit and still more rarely the tomato leaves. The symptoms on the fruit begin as a small watersoaked or greasy-looking spot which rapidly increases until the whole fruit is involved. Finally the whole fruit may soften and collapse. Before this it may show white mold on the outside, and at the edge of the decayed part a slight brownish discoloration. This discoloration is always very slight and never is in zonations or is "buckeye"-like. The fungus attacks mostly only the green fruit. After ripening begins the fruit is fairly resistant. The effect on the foliage is a blackening and shriveling after the white mold has appeared on the lower leaf surface.

Control

Since the potato fungus occurs so rarely on tomatoes, no control measures are suggested. Spraying with bordeaux mixture or dusting with copper-lime dust, if begun early enough, will hold the fungus in check.

BLOSSOM-END-ROT

(Caused by undesirable environmental conditions)

The first symptom of blossom-end-rot is a slight water-soaked area about the blossom-end. The lesion soon darkens and enlarges in a constantly widening circle until the fruit begins to ripen. The decaying spot may be merely a speck or it may involve half or even more of the tomato. Sudden lack of water is the principal cause of the trouble.

Control

Inasmuch as blossom-end-rot is so closely related with the water supply, the one important step in controlling the disease is governing the moisture supply in the soil. The land should be well drained, and plenty of humus should be available to retain the moisture during a dry period. If drought occurs, the cultivating should be very shallow, so that only enough soil is stirred to fill any cracks that may appear and to kill the weeds. Surface scraping even may be preferable. In wet weather, the soil should be stirred enough to cause the evaporation of excess water.

In the hotbeds or the greenhouse young plants should not be grown too quickly nor unusually slowly. The plants also should not be subjected to too sudden and severe hardening before planting. A steady growth, both as a seedling and as a plant in the field, will eliminate much of the

trouble. The varieties of tomatoes that are most resistant to leaf-blight usually suffer most from the blossom-end-rot. A defoliated plant usually does not have the disease. It, however, has not proved profitable to remove the foliage in order to protect the fruit from blossom-end-rot.

CARROT

On Long Island much loss has been caused by carrot weevil and some by leaf blights.

CARROT WEEVIL

(*Listronotus latiusculus* Boheman)

On Long Island early crops of carrots are subject to attack by the larvae of a small dark brownish weevil which in some cases ruins as much as 75 per cent of the crop. The insect injures also curled-leaved parsley, hymicha, and dill. Its principal wild food plant in this area is wild carrot. Most of the damage is done by the larvae. Badly injured carrots are almost unsalable. The injury to the parsley roots induces a yellowish sickly condition of the leaves, greatly reducting their market value. With hymicha the injury to the roots may be severe enough to render them unsalable.

The carrot weevil hibernates in the adult stage in the immediate vicinity of the infested fields. The beetles appear in May and soon begin to deposit eggs. The female first hollows out a cavity in a leafstalk in which she deposits 3 or 4 eggs, sealing up the opening with a blackish substance. The eggs hatch in about ten days, and the young grub begins feeding on the inside of the stalk. It usually burrows downward and generally enters the root without coming to the surface, but some of the grubs, hatching in cavities at some distance from the base, leave the stem and either fall or crawl to the ground where they soon find their way into the carrot itself. Usually several larvae attack a single carrot. Feeding is usually confined to the upper and the outer part of the root. The burrows take a zig-zag course and often coalesce, producing large areas in which most of the surface tissue of the carrot has been destroyed.

The larva becomes mature in about two weeks, leaves the root, and transforms to a pupa in an earthen cell within an inch or so of the carrot in which it developed. From six to twelve days are spent in the pupal stage. The beetles of the second brood appear in July, and lay eggs for a second brood of larvae which injure the carrots during August. A partial third brood may develop but causes little injury to late carrots and is unimportant.

Control

Although the weevils are provided with wings, they seem to use them very little, and the migration from field to field takes place very slowly. For

this reason carrots can be grown free from injury even in badly infested localities by selecting for carrots fields not recently used for this crop or for curled-leaved parsley, hymicha, or dill. Careful attention to the proper rotation of crops seems to give an entirely satisfactory solution of the carrot-weevil problem.

LEAF BLIGHTS

(Caused by *Macrosporium* and *Cercospora*)

The carrot leaf blights affect the leaves and the petioles, which turn yellow and then change to brown. During severe infection, the whole top of the plant may be killed. Both fungi may overwinter in the old diseased carrot refuse and also with the seed. It is not known whether they can live in the soil in the absence of carrot refuse. They are most virulent when the air temperatures and the humidity are fairly high. Consequently the disease usually causes most damage late in the summer, but before the cooler days of autumn have come. Ordinarily neither blight is present early in the summer.

Control

Spraying with bordeaux mixture, 4–4–50, or dusting with copper-lime dust, 20–80, at weekly intervals, beginning when the plants are about 3 inches tall, controls the disease. Horse-drawn machines cannot well be used; therefore it may be necessary to use hand machines or small tractors. No form of arsenate should be added to the fungicide since it seems to stunt the plants.

KNOB CELERY AND CELERY

In some areas the carrot rust-fly has injured celery seriously. The leaf blights are prevalent during any year when the rainfall is more than average. Spraying or dusting in the seedbed and field and care in the rotation with carrots to avoid the fly are important control measures.

BLIGHTS

Late blight (*Septoria apii*)
Early blight (*Cercospora apii*)
Bacterial blight (*Bacterium apii*)

Three separate and distinct blights, all controlled by the same means, attack knob celery and celery and are characterized as follows: (1) Early, or Cercospora, blight produces dead, ashen-gray velvety areas; (2) late, or Septoria, blight causes brown spots on the leaves and the stems, in which are the tiny, black, fruiting bodies of the fungus; and (3) bacterial blight produces spots that are more reddish brown than those of late blight, have a yellow halo about the lesion, and do not contain black fruiting bodies. Characteristic symptoms may appear on both the leaf blade and the petiole.

or stalk, of the plant at any stage of its development. Plants in the seedbed as well as in the field are subject to attack.

The effect of the celery blights is to lessen the attractiveness of the product and thus decrease its market value. When present to any extent, they also retard growth, materially reduce the yield, and lessen the keeping quality of the crop. All of them live over from year to year in the diseased portions of the plants which remain in the field after the marketable celery has been removed, and late blight may be carried with the seed. Early in the season the incubation period of the casual organism is probably from a week to ten days, while later in the season it may be much longer. Infection of the leaves and the spread of the disease is favored by rain and by moisture on the plant.

Control

Soil for the seedbed should be selected from that which has not grown celery for more than three years, and which is free from celery refuse. This selection of the bed should be accompanied by thorough spraying with bordeaux mixture, 5–5–50, or dusting with copper-lime dust. Weekly applications are made in the seedbed; the applications at this time being very important. This is followed by spraying or dusting in the field.

It is recommended that spraying be started as soon as the plants become established in the field and be continued throughout the season at intervals of a week to ten days. The spray or the dust should be applied to the plants just before cultivation, for, if any old diseased refuse is in the soil, the cultivator will drag it to the surface of the soil, where it will fruit and cause infection if the foliage is not protected. If the disease does not appear three weeks prior to harvest time, continued spraying probably is not essential.

Even though spraying is done, as long rotations as possible should be practiced, and the diseased refuse left in the field should be plowed under deeply or burned.

Where an overhead watering system is used, the watering should be done in the morning fully an hour after the dew has dried from the foliage. It takes at least fifteen hours of continuous wetting for spore germination; therefore, if the watering is done early in the evening or in the morning before the dew is removed, the leaves may stay wet long enough for infection to take place.

Seed treatment has not proved beneficial under New York conditions.

ASPARAGUS

The Washington varieties of asparagus have solved the rust problem. If, in addition to choosing these varieties, the control measures are followed for the eradication of the beetle, nearly all troubles of the asparagus crop are eliminated.

RUST

(Caused by *Puccinia asparagi*)

At present there are no serious diseases of asparagus. Rust may be present occasionally. The bushy tops of the plants become covered with reddish or black pustules. This prevents the normal manufacture of food and its storage in the roots, thus decreasing the succeeding season's yield. The rust overwinters mostly in the form of teliospores that can cause infection on the young shoots in the spring. The rust fungus thrives best where there are few dashing rains but where dew or fog is prevalent. Dry soils are favorable for its development.

Control

It is advisable to burn the diseased tops late in the fall. During the cutting season, all plants should be kept cut. Only resistant varieties should be planted. Among these, Palmetto and Argenteuil are fairly safe. The most resistant ones, however, are Mary Washington and Martha Washington, which are being used so generally that rust is now only rarely found in New York.

ASPARAGUS BEETLES

(*Crioceris asparagi* Linnaeus and *C. duodecimpunctata* Linnaeus)

Two closely related beetles attack asparagus in New York. Both species are about ¼ inch in length. The head, the underparts, the legs, and the antennae of the common asparagus beetle are bluish black in color; the markings on the wing covers vary greatly. The inner margin of each wing cover is bluish black, the outer margin and the tip are orange, and the intervening space is yellowish white, broken into three spots by bluish crossbands. The twelve-spotted species is reddish orange in color; the wing covers are marked with twelve distinct black spots. The dark gray slug-like larvae of the common asparagus beetle feed openly on the leaves; the larvae of the twelve-spotted species feed inside the berries. The adults of both species emerge from winter quarters at the time the young asparagus shoots are just coming up. They attack the tender tips, eating out holes and producing a brownish discoloration of the tissue. The adults of both species and the larvae of the common species attack also the leaves, often nearly defoliating the plants and seriously interfering with their growth. The beetles also eat out irregular areas in the bark or rind of the stems, giving them a spotted appearance.

Control

In asparagus fields in which the crop is being cut for market, the injury to the young shoots by the larvae may be prevented by cutting the crop clean every three to five days. In this way all the eggs deposited on the

shoots will be removed before or very soon after hatching. All volunteer plants should be destroyed, but it will often pay to leave a row here and there uncut to serve as a trap on which the beetles will congregate, feed, and lay their eggs. Here they may be poisoned by an application of calcium arsenate. After the cutting season is over, the plant may be protected from beetle injury by two or three applications of calcium-arsenate dust, 15 pounds mixed with 85 pounds of hydrated lime.

The use of poultry for the destruction of the beetles is practiced with good results in some localities. The asparagus field is surrounded with a chicken-wire fence, and poultry are allowed the run of the field. Thirty or forty hens are sufficient to keep a two-acre field practically free from the beetles during the early part of the season. When the plants have grown to a considerable height, some of the beetles will be out of reach of the hens, and the beetles may be abundant in the fall. It is rarely necessary however, to resort to spraying in fields in which poultry are allowed to run.

SWEET CORN

Aside from the bacterial wilt, or Stewart's disease, and the corn ear-worm the insects and diseases of corn in New York State are generally not of a serious enough nature to require control measures. An occasional field may have much smut, and in some sections the corn-borer is a menace. Crop sanitation is then the best recommendation.

BACTERIAL WILT, OR STEWART'S DISEASE

(Caused by *Aplanobacter stewarti*)

During the seasons of 1931 to 1933 sweet corn grown along Lake Erie, the lower Hudson Valley, and Long Island, was seriously affected with the bacterial wilt. Reports came also from New Jersey, Pennsylvania, and Ohio that an epidemic of this disease was present in these States. Such a widespread prevalence of a serious form of this disease is unusual, since in past years it has never been threatening. At present it is not possible to state whether the organism is becoming more generally prevalent or whether the increase of the trouble is due merely to the high temperatures of the past few summers and will abate with the coming of cooler growing seasons.

The very early yellow varieties of sweet corn now being grown so commonly are much more susceptible than are the older, late-maturing, white types, which are fairly resistant. Popcorn and flint corn also are fairly susceptible, while the dent field corns are almost immune.

The disease makes its appearance at any stage of growth, but usually is most noticeable when the plants have attained a height of several feet.

The plants are dwarfed; the tassel develops prematurely, whitens, and dies early; the leaves dry out one by one much as if frosted; and finally the stem dies and dries, but without becoming soft-rotted. A yellow slime ooze may collect on the surface of the inner husks. If the stem is cut off near the base and pressed, a similar yellow ooze collects at the cut ends of the "strings" in the stalk. This is the one means by which the disease can be differentiated from any other corn trouble.

The life history of the parasite is not fully known. The foremost question at present is whether it can overwinter in the soil. It has been proved that it can live through the winter in the seed and in the old diseased stalks. The twelve-spotted cucumber beetle (Southern corn-root maggot) carries the organism from these old stalks to the young plants of the new crop. The pathogene then is further disseminated by several species of flea beetles.

The bacterium is very susceptible to its environmental conditions. It takes at least two successive summers with high temperatures to bring about an epidemic, while in a cool season only the most susceptible varieties are affected. The amount of rainfall at planting time too has a great influence on the severity of infection, a heavy rain being especially favorable for the bacterium. In addition, the date of planting is very important; the earlier the seed is put into the ground, the more chance there seems to be for heavy infection.

Control

The infected plants should be destroyed, either by burning or placing into the silo, as soon as the harvesting is completed. Fall plowing, turning the stubble under deeply, also is of help. Furthermore, next year's sweet-corn crop should be planted as far from the present field as possible. If susceptible varieties must be planted, the seed should be obtained from the North so that there is less chance of seed infection. Planting should be delayed as long as the market price or time of maturity will permit. Even the most susceptible varieties may sometimes be grown in a comparatively healthy condition if they are planted late.

One of the most hopeful methods of control that has been developed lately is the use of resistant varieties. Some such strains have been bred by one of the men working at Purdue University for the United States Department of Agriculture. Such strains as Golden Cross Bantam, Purdue Bantam, and Top Cross Bantam, can now be obtained from local seed dealers. Before being planted in large quantities these selections should be given a trial by the individual grower to make sure that they will meet his market requirements and will mature early enough.

Seed treatment has been advocated, but did not prove successful where the insect carriers were numerous.

SMUT

(Caused by *Ustilago zeae*)

The smut of corn probably was present when the white man first came to America. It is now present in nearly all countries where corn is grown, being of great economic importance in North America.

Sweet corn is more susceptible than is field corn, and under very favorable conditions may become infected during the seedling stage.

The corn plant may be infected at any time in the early stages of its development, but gradually grows less susceptible after the formation of the ear. Any part of the plant aboveground may be invaded, although it is more common to see smut boils on the ears, the tassels, and the nodes than on the leaves, the inter-nodes, and the aerial roots. The boil is composed of a white smooth covering enclosing a great mass, sometimes 4 or 5 inches in diameter, of black greasy or powdery spores. After the maturity of the spores, the covering becomes dry and brittle, breaks open, and permits the black powdery contents to escape. The smut spores are blown long distances by the wind and are particularly prevalent if there is much dust in the air. They will germinate in ordinary rain water but germinate very much more prolifically in the drainings from barnyard manure. Consequently, it is scattered over the farm with manure and has been known occasionally to pass through the digestive tract of animals without losing its germinating ability. The germ tube of the germinating spore ordinarily does not enter the plant directly, but a few drops of dew caught in the leaf sheath will remain long enough for the fungus to start a luxuriant growth, and it is only when it is growing in this manner that it can enter the plant.

Hot dry seasons are favorable for the growth of the smut fungus, although drought is only an indirect cause of the smut increase. When the soil is dry, the dust can blow more readily, and it is by means of air-floating dust that the fungus spores are carried from one farm to the other. Furthermore, when there is a drought, the temperature usually is high, which is especially favorable for the germination of the spores.

Control

It is to be remembered that the seed dealer or the seed grower is not to be blamed for the smut that the gardener may have on his crop, for the smut is not transmitted with the seed. Therefore, seed treatment is never of any value.

There is only one control measure, and that one is rather unsatisfactory. If every grower in a given community will go through his field two or three times during the season and cut out all of the smut balls before they have time to break open, and remove them in some receptacle that will not permit the spores to be spilled, the smut can be reduced. The material that is cut out should be buried deeply or placed on a hot enough fire to be

destroyed. One year of cutting is not sufficient to cause much difference in the amount of the disease; but, if this cutting is continued for two or more years, the smut will gradually be eliminated. This is true, however, only if adjoining neighbors cooperate in following the same recommendation. The removal of the smut should in each case be accompanied by rather long crop rotations.

CORN EAR-WORM

(*Heliothis obsoleta* Fabricius)

The corn ear-worm is a native insect much more abundant and destructive in the South than in New York. It is often confused with the European corn-borer. The amount of damage caused by the ear-worm varies greatly from year to year, depending largely on the locality and the length of the growing season. It is always more injurious on Long Island than in the rest of the State, the loss to late sweet corn sometimes amounting to one-half or more of the crop. In the rest of the State the insect causes little or no damage during many years, but occasionally the late crop may be seriously injured. Injury is likely to occur up-state only in years when the growing season is long and warm.

Under New York conditions the corn ear-worm hibernates in the pupal stage in the ground. The moths emerge in the early spring over a rather long period, a month or more. The moth has a wing spread of about 1½ inches. The front wings are straw-colored, usually marked with a dark spot in the middle; the hind wings are creamy white, with a blackish border and a dark spot near the middle. The moth deposits her eggs on the leaves, the tassels, and the silk of corn, the silk being preferred above all others for oviposition. During the early part of the season before corn is available, the insect breeds on other plants, including several common weeds. Under New York conditions, the principal injury is caused by the larvae feeding inside the husk on the kernels of corn. The young larvae quickly work their way down through the green silk and in a few minutes reach the top of the ear. They then begin to feed on the silk and the unripe kernels under the husk. The injured kernels and the excrement left by the larvae in its burrow serve as a medium for the growth of molds and bacteria which greatly augment the injury inflicted by the insect.

Control

No practical method of controlling the corn ear-worm on corn has been discovered.

EUROPEAN CORN-BORER

(*Pyrausta nubialis* Hübner)

The European corn-borer is now generally distributed throughout Long Island. East of Wading River the insect belongs to the race having two

generations a year, while in the western part of the Island there is but a single brood. The borer is much more destructive to corn where two generations develop than where there is a single brood, and furthermore a larger number of crops are attacked. In the eastern part of the Island, potatoes, lima beans, and beets, as well as corn, are often infested.

When full-grown, the corn-borer larva is nearly 1 inch in length, is dirty white in color, has a brownish head, and is marked with transverse rows of small dark spots on the segments of the body. The borers may be found in all parts of the plant aboveground, where they burrow through the pith of the stalk, the stem that supports the ear, and the tassel stem. They enter also the midrib of the leaves, and are often found in the ears, feeding upon the silk, the husk, the unripe kernels, and burrowing in the cob. When abundant, they so weaken the stalk that the plant breaks over. Their presence on the ears of sweet corn makes the ears undesirable for use as green corn and greatly increases the cost of canning because of the expense of sorting out the infested ears.

The corn-borer passes the winter in the larval stage in its food plant unless it is disturbed, in which case it may migrate to some more suitable shelter. The borers are therefore often found in stems of rank weeds growing near-by the cornfield, in piles of leaves, in the crevices of fences, and in similar situations. In the spring the larvae transform within their burrows to brownish pupae, and about ten days to two weeks later the moths emerge. The moths have a wing spread of about 1 inch. The female moth is pale yellow in color, with darker irregular lines across the wings. The male moth is slightly smaller than the female and is much darker. When at rest, they fold their wings and appear triangular in shape. They are strong fliers, and with favorable winds may be carried for many miles. They are active mostly at night, but are rarely attracted to lights. The moths of the spring brood are to be found in the fields for a period of from a month to six weeks during early summer. They deposit their eggs mostly on the underside of corn leaves in flat, compact clusters, each containing, on the average, from 15 to 20 eggs. The eggs are thin, flat, and scale like, and are usually shingled one over the other in the cluster. Each female moth is capable of laying about 400 eggs. On hatching, the young corn-borers may feed for a short time on the surface of the leaves, but they soon find their way into the plant, often entering at the base of the leaves. They then burrow up or down the stalk, where they feed on the sweeter and more succulent tissues. They are often found at the base of the tassel stem, which is so weakened that it is easily broken over by the wind. These broken tassels are readily seen and serve to indicate the presence of the borer. The larvae becomes full-grown in about a month, having moulted, on the average, four or five times. Sometimes they molt six or seven times.

It is a curious fact that in New England the corn-borer has two generations a year, while in the rest of the country there is usually only one. The two-brood form is found in the eastern part of Suffolk County, while the single-brood variety occurs in other parts of New York. In the two-brood form most of the larvae pupate soon after reaching maturity and give rise to a second brood of moths in August and early September. These lay eggs and produce a brood of larvae which reach maturity in time to go into hibernation before the advent of cold weather.

In addition to corn, the corn-borer attacks a number of cultivated crops, such as rhubarb, beets, celery, and beans, but the infestation is not likely to be severe unless these crops are grown near infested corn fields. Under such conditions, millet, sorghum, and buckwheat may also be attacked, as well as a number of coarse-stemmed garden flowers, such as dahlias, chrysanthemums, gladioli, and the like. The corn-borer may also breed in a number of rank weeds, such as barnyard grass, cocklebur, smartweed, pigweed, and ragweed.

Control

The corn-borer has been found to be a very difficult insect to control. The larvae are not readily reached by insecticides, feeding as they do principally inside the plant; and the moths are but little attracted to lights, making it impossible to trap them. Recourse must be had to the destruction of the overwintering larvae. Except in areas of excessive infestation, most of the larvae are to be found during the winter in the corn plants or in large-stemmed weeds growing near-by. If the corn is cut close to the ground, and as early as the maturity of the crop will permit, few of the borers will be left in the stubble; if the stalks are utilized for ensilage in the usual way, most of the borers will be destroyed. If the stalks are fed whole to cattle and the uneaten portions are tramped down in the barnyard, the greater proportion of the borers will be killed. To destroy all those that escape, all such material should be spread out in a field and plowed under early the next spring. It is better, however, to either chop or shred corn fodder that is to be fed in this way.

Cornfields should be plowed either in the fall or early in the spring, taking great care to cover all the stubble and the pieces of stalks that might harbor borers. If this is done, the borers will find themselves in unnatural conditions, and most of them will leave the buried stalks to seek a more suitable hiding place. If the surface of the field is clear of all litter, nearly all of the borers will fall prey to their natural enemies or succumb to exposure. In order to avoid bringing the stubble and the stalks to the surface when fitting the land, it is advisable to use a disc harrow for this purpose. All weeds, both on the field and up to 10 yards from the edge of the corn, should be plowed under or burned.

Since the moths can fly for considerable distances, the individual farmer cannot hope to succeed in controlling the corn-borer no matter how carefully nor persistently he practices these methods. To be effective, these practices must be employed by all the corn growers in a considerable area.

The Federal Government has been liberating large numbers of parasites of the corn-borer in eastern Long Island with the purpose of establishing a natural check on the abundance of the insect in that region.

EGGPLANT

BLIGHT

(Caused by *Phomopsis vexans*)

Most of New York State is too far north for serious trouble with the blight, but there are certain seasons on Long Island and Staten Island when the temperature reaches the height favorable for the growth of the fungus. So far as is known it affects no other crop.

The fungus may cause trouble at any stage in the development of the plant from the damping-off of day-old seedlings to the rotting of ripe fruit. The young plants blacken and die. The leaves of older plants may be peppered with so many brown spots that they wither. The most serious phase of the disease, however, is the fruit rot. The fruit turns black, shrivels, and is covered with minute black pimples, which are the fruiting bodies of the fungus.

The parasite overwinters in and on the seed, as well as in old diseased refuse, and can remain alive in the soil for at least three years. Aside from the high temperatures, it is not much affected by environmental conditions. The more rainfall, the more chance there is of heavy infection.

Control

The first requirement in control is crop rotation of four or more years. An attempt should be made also to procure healthy stock. If the grower saves his own eggplant seed, these should be taken from fruits that are without blemish. Northern-grown seed is more desirable than southern seed, which is almost sure to be infected. Only bright-colored seed should be planted. If an appreciable proportion of the seeds show black spots, the whole lot should be discarded. Seeds of unknown origin should be treated by tying them loosely in cheesecloth and dipping the bag of seeds for ten minutes in a corrosive-sublimate solution (1 tablet of the powder for each pint of water). After rinsing well in clean water, the seeds are dried, then shaken up with red cuprous oxide (which is red and fluffy and not black—1 tablespoonful for each pound of seed). The seed should be planted soon after treatment.

Spraying the plants each week in the seedbed with 3–3–50 bordeaux mixture or dusting them with 20–80 copper-lime dust helps to protect the plants from the blight fungus. Similar applications can be made also in the field if the blight has appeared frequently enough to justify the expense.

Picking affected fruits as soon as the disease appears, and destroying them by burying or in some other manner, reduces very much the amount of inoculating material, and has helped to retard the spread of blight during the current season as well as to reduce the amount of disease the following year.

WILT

(Caused by *Verticillium alboatrum*)

The fungus that causes eggplant wilt affects many other cultivated and weed hosts. Among these are some as far apart in the plant classification as peaches, tomatoes, and black raspberries. The disease probably is present wherever eggplants are grown, and is so serious, when it once becomes well established, that in many localities the growing of the crop is no longer profitable.

The wilt starts early in the life of the plant but usually is not noticeable until the crop is fairly well grown. Then some of the plants may be smaller than the others, the leaves may turn yellow, then brown between the veins, so that the whole plant lingers half alive during the remainder of the season or wilts and dies soon. The tissue beneath the bark of the stem is discolored. The fruit is not affected, at least directly, by this disease.

So far as is known the pathogene is not carried with the seed. After once being introduced the Verticillium lives for many years in the soil. It may be brought in with soil on the roots of transplants or in other ways in which soil organisms may be disseminated. It appears not to be much affected by temperature but does require at least a moderate amount of soil moisture for best growth. It seems to thrive better in sandy soil or sandy loam than in heavy clay. But most important of all, the fungus grows best when the soil is alkaline, and grows only slowly when the soil is very acid.

Control

Seed treatment and spraying or dusting are of no value in controlling this fungus. When once the wilt has become generally prevalent in any given field, eggplant should not be planted in that field for many years. A new field should be chosen which for ten years or more has not produced wilt-infected potatoes, tomatoes, or any of the other susceptible crops.

The application of sulfur to the soil has been suggested for the control of wilt. The more newly cultivated soils on Long Island usually are very acid, so sulfur is not suggested. Besides, if other crops are to be grown on

this land, the sulfur will prove harmful. Consequently, it would be better to use a different field each year for eggplant, choosing those with the most acid soils.

Breeding strains for resistance has proved very discouraging.

COLORADO POTATO BEETLE

(*Leptinotarsa decemlineata* Say)

The common striped potato beetle sometimes completely defoliates eggplants. The injury may be prevented by dusting the plants with a mixture of 20 pounds of calcium arsenate and 80 pounds of hydrated lime.

The potato flea-beetle (*Epitrix cucumeris* Harris) often riddles the leaves of the young plants with holes. Dusting with the same mixture will tend to reduce the injury.

PEPPER

FRUIT SPOTS

(Caused by numerous organisms)

The fruits of pepper seem to be the ideal place on which fungi and bacteria can grow. Especially is this true if sunscald has taken place. Consequently the various fruit spots found on this crop in the summer may be caused by any one of the following organisms or by a combination of two or more: *Cercospora*, *Bacterium*, *Gloeosporium*, *Colletotrichum*, *Macrosporium*, or *Phoma destructiva*. When the weather is warm and damp, the fruit rot may become serious in its extent and destructiveness. No definite control measures are known for all of them, but it has been found that treating the seed with copper-sulfate solution or with red-cuprous-oxide dust as suggested for the control of damping-off (page 81) and then spraying or dusting in the seedbed and in the field as suggested for the control of celery blights (page 69) will keep the foliage intact and consequently reduce the rots on the fruit.

MOSAIC

Mosaic of pepper is the same as that of tomato (page 64).

SPINACH APHIS

(*Myzus persicae* Sulzer)

The spinach aphis often seriously attacks peppers. It may be controlled by dusting with a 3-per-cent-nicotine–lime dust. Refer to page 35.

CUTWORM CONTROL

The means employed for the control of cutworms will vary according to the crop, the conditions under which it is grown, and on the habits on the species causing the injury.

In small vegetable gardens and greenhouses hand-picking may be practiced to advantage. Careful watch of the plants should be kept, and, whenever injury is noticed, the soil around the base of the plant should be searched and the cutworms destroyed. Shingles or small boards laid about the beds will form attractive hiding places for the worms during the day; here they may be easily found and destroyed. When such plants as tomatoes are transplanted, they may be protected by using cardboard or tin cylinders sunk a short distance in the soil. Tin cans with the top and the bottom removed are convenient for this purpose. Greenhouses often become infested by cutworms in the rotted sod used in the beds. This may be prevented if the soil is sterilized by steam before it is used.

Probably the most practical, cheap, and convenient method of cutworm control is the use of poisoned baits. These may be employed equally as well in the home garden, the greenhouse, or the field. A bait made according to the following formula has been found effective against the variegated cutworm and others of similar habits:

Bran		20 pounds
Paris green		1 pound
Molasses		2 quarts
Orange or lemons		3 fruits
Water	(about)	3½ gallons

A cutworm bait made according to the following formula is somewhat cheaper and nearly, if not quite, as effective as that given above:

Bran		25 pounds
White arsenic		¾ pound
Water	(about)	3 gallons

The dry bran and the paris green are thoroughly mixed in a tub or similar receptacle. The juice of the oranges or lemons is squeezed into the water; the remaining pulp and peel is chopped into fine bits and added to the water. The molasses is dissolved in the water and the bran and the poison are wet with it, the mixture being constantly stirred so as to dampen the mash thoroughly. Only enough water should be used to just moisten the mash; the mash should not be sloppy.

This quantity of bait will treat about 3 acres. The material should be scattered broadcast evenly over the infested area at nightfall. If applied during the day, it dries out and is not then attractive to the cutworms. In the garden or the greenhouse a small quantity of the bait may be placed near each plant.

LEAF-SPOTS OF VEGETABLES

Nearly every vegetable crop has one or more leaf-spots which usually are not considered of importance, but if the combination of temperature and moisture are just right for the parasite, the trouble may flare up and cause considerable loss. It is difficult to give control measures, either because

the disease does not ordinarily come often enough to justify the expense of applying a fungicide, or the growth of the plant is such that it is extremely difficult to apply spray or dust. Among such crops are schaff, with Ramularia and Cercospora leaf-spots; salsify, with white rust; lettuce, with Septoria leaf-spot; pepper, with Alternaria leaf blight; parsnip; horseradish; parsley; rhubarb; spinach; beet; and dandelion.

Control

In so far as possible it always is desirable to destroy diseased refuse, to rotate crops, and to get healthy seed. If the grower thinks that he has suffered enough loss of crop to justify it, and the plants will not be disfigured for market with the fungicide, he can protect the plants by frequent applications of bordeaux mixture, 3–3–50, or by dusting with copper-lime dust, 15–85, or 20–80.

DAMPING-OFF, BLACK-ROOT, OR WIRE-STEM IN THE SEEDBED

(Caused by various soil fungi)

There are in the soil a half dozen or more fungous parasites that cause damping-off. They usually grow very near the surface, and enter the plant at the point where the seedling emerges from the ground. All of them require for quick growth a high moisture content of the soil and the air.

Control

If the air and the surface of the soil are kept as dry as is consistent with good growth of the plant, damping-off can fairly well be held in check. In addition, the seed should be sown thinly enough in the bed so that later the plants will not be crowded. The beds in coldframes should be protected from fog or excessive rain. If the soil in the bed is heavy and slow-drying, it can be improved by mixing with it a small amount of sand or by sprinkling sand over the surface. The watering should be done in the morning and preferably on bright days. Heavy applications of water at long intervals are more desirable than are frequent light sprinklings. Stirring the surface soil after an application of water helps it to dry and thereby reduces the chances of damping-off.

Correct conditions cannot always be maintained, particularly in hotbeds or in low greenhouses. Tight wooden rooms or metal boilers can be built, or bought, into which flats filled with dirt can be piled, and steam forced in until the soil is sterilized. If nematodes are not present, the soil may be drenched with formaldehyde, one part in forty-nine parts of water. Where steam or formaldehyde sterilization cannot be practiced, the application of another fungicide is desirable. It has been found that copper com-

pounds, as copper carbonate and others, will quickly kill certain damping-off fungi. They, however, have little effect on Rhizoctonia. Corrosive sublimate, on the other hand, is very toxic to all the damping-off fungi that have been tested so far, including Rhizoctonia.

The copper carbonate, which will not dissolve, is mixed with 25 gallons of water, and poured over the newly seeded soil at the rate of 1 pint for each square foot of surface or it is poured along the row as the plants are coming through the ground. It may be applied later at the rate of 1 pint for each 5 feet of row. The applications are repeated as often as found necessary.

One ounce of corrosive sublimate (mercuric chloride) is dissolved in a little hot water and then diluted to 15 gallons. One pint of this solution may be applied to each square foot of soil at seeding time. There is more danger of seed injury with the use of corrosive sublimate than with copper carbonate; therefore a test should be made before large areas are treated to make sure that the conditions and the nature of the crop will permit the use of mercury compounds. When the seedlings are up, the applications are made in the same manner as that recommended for copper carbonate. Cabbage, cauliflower, and brussels-sprouts seedbeds are treated with the corrosive sublimate as suggested for the control of cabbage root-maggot (page 6).

There are various organic mercury compounds on the market that have been used successfully by some growers. These compounds should always be applied according to the directions on the container.

In a recent bulletin from the New York State Agricultural Experiment Station, Dr. Horsfall has shown that in many cases damping-off of vegetable seedlings can be controlled by treating the seed with copper sulfate (blue vitriol solution) or red-cuprous-oxide dust.

One pound of blue vitriol is dissolved in 8 gallons of water, and the seeds, after being tied loosely in cheesecloth, are soaked in this solution for an hour or more. After this treatment, the seeds are removed and dried, or blotted with newspaper, and are then mixed with dry sand so that they may be handled readily; they should be planted immediately. They are not washed with water after the immersion in the copper solution.

The second treatment is with red cuprous oxide. A pound of the seeds is placed in a quart fruit jar and a rounded teaspoonful of the dust is sprinkled over them. The jar is then closed tightly and shaken until every seed has a coating of the dust. The treated seeds are planted in the usual manner.

These treatments with the copper compounds have proved especially successful in the case of tomato, spinach, beets, peppers, and eggplant, and have been satisfactory on a number of other vegetable seeds, such as peas, cucumber, salsify, and melons.

Some vegetable seeds, such as those of celery and lettuce, are so delicate

that nearly any kind of seed treatment injures them. In such cases the only control for damping-off is soil sterilization. The most effective way for such sterilization is with steam. A cheap portable boiler can often be obtained secondhand so that the outlay of capital will not be too great. A steam pan can be built at home to fit the width of the cold frame or hotbed. Enough steam is forced under the pan to raise the temperature of the soil to at least 160°F. for fifteen minutes or longer. When steam is not available, formaldehyde may be diluted, 1 gallon in 49 gallons of water, and a half gallon of the dilution mixed with each square foot of soil. Seeds cannot be planted then until the soil has dried and the fumes of the formaldehyde have disappeared. Some growers prefer to use the formaldehyde in the form of a dust, which is now on the market. The directions on the container should be followed closely if the dust is applied. Furthermore, the soil should be wet down thoroughly after the application, or injury may result. (For details regarding soil sterilization, refer to Cornell Extension Bulletin 217, "Soil Treatments for the Control of Diseases in the Greenhouse and the Seedbed".)

INSECTICIDES AND FUNGICIDES

BORDEAUX MIXTURE

Almost the only spray used on vegetables is bordeaux mixture. This is made by mixing a solution of copper sulfate (blue vitriol) with milk of lime. A mixture made from 4 pounds of copper sulfate and 4 pounds of lime to 50 gallons of water is indicated by the formula 4–4–50; 5 pounds of copper sulfate and 5 pounds of lime to 50 gallons of water, by 5–5–50, and so on. In order to make bordeaux mixture of any strength, the procedure should be as follows:

A stock solution of copper sulfate is made in a barrel from 50 pounds of copper sulfate dissolved in 50 gallons of water. If the crystals, placed in a gunny sack, are suspended just beneath the surface of the water, they will dissolve in the course of three or four hours.

A stock mixture of lime is made by mixing 50 pounds of freshly hydrated lime in 50 gallons of water. Some investigators prefer 50 pounds of freshly slaked burned lime in place of the hydrated material. Air-slaked lime should not be used.

The sprayer is filled three-fourths full of water. If a 4–4–50 solution is desired, 4 gallons of copper sulfate stock solution is added to this water for every 50 gallons of mixture to be made. The solution requires stirring until it is well diluted, after which 4 gallons of the stock mixture of milk of lime is added to each 50 gallons of the mixture. The lime water is run through a strainer in order to prevent the larger particles of lime from getting into the spray tank. While the milk of lime is being added to the

dilute copper-sulfate solution in the sprayer tank, the material in the tank should be stirred constantly. The sky-blue bordeaux mixture will result. Enough water to make the required amount of mixture must now be added. The milk of lime may be added first if desired. If too much lime is added, the bordeaux will not stick well to the plant so that the same number of pounds of lime as there are of blue vitriol in the mixture should be used, and in some cases even a smaller amount is desirable. Calcium arsenate or lead arsenate may be added to the bordeaux mixture if insects are to be controlled. For making small quantities of the fungicide, 4 ounces of copper sulfate, 4 ounces of hydrated lime, and 3 gallons of water are necessary.

If only a small amount of the spray material is required, prepared bordeaux mixtures are available on the market and prove handy. But in larger quantities they are expensive as compared with the home-mixed material.

COPPER-LIME DUST

Some growers prefer the use of dust instead of the liquid application. The dust is made of copper sulfate (blue vitriol), the best grade of chemical hydrated lime, and sometimes calcium arsenate. The copper sulfate is dried thoroughly and ground exceedingly fine. This is then put on the market as monohydrated copper sulfate. It may be bought already mixed with the lime or obtained separately and mixed at home. The formula for the dust is 15 pounds of the copper sulfate and 85 pounds of the lime. If 15 pounds of calcium arsenate is added, the formula is written 15–15–70.

The dusting can be done only when the plants are wet with dew or rain. If the dust is put on when the foliage is dry, the copper is washed off by the next shower and will be of no value. For this reason the dusting is done late in the evening or just after daybreak. All parts of the plant should be covered thoroughly. It is not enough merely to walk along one side of a vegetable row and apply the dust with a hand machine. It is necessary to move the nozzles from one side to the other and at different angles, so that every leaf is treated uniformly. If a horse-drawn duster is used, there should be three nozzles for each row of plants except when the plants are very small. One of the nozzles should be directed straight downward and one on each side of the row directed inward at the same angle that the branches or the leaves of the plant extend from the main stem.

NICOTINE

For spraying purposes, nicotine is usually sold in the form of nicotine sulfate. The standard brands of nicotine sulfate on the market contain 40 per cent of nicotine. The recommendations in this bulletin are based on a product of that strength. Nicotine sulfate is not volatile, but the

fumes of the nicotine are liberated when the material is applied as a spray in combination with soap. Nicotine sulfate is not effective when mixed with water only. It is not so effective in combination with bordeaux mixture as when used with soap.

For greenhouse use, nicotine is often sold in the form of a 40-per-cent solution, the nicotine being in the "free," or uncombined, form.

Nicotine dust is usually made by mixing nicotine sulfate with hydrated lime. Nicotine-lime dusts can be bought ready mixed, or they may be prepared at home in a ball mixer or in a self-mixing duster. Since the commercial brands of nicotine sulfate contain 40 per cent, by weight, of nicotine, 5 pounds, or 2 quarts, of this material is added to 95 pounds of hydrated lime to give a dust containing 2 per cent of nicotine. For a 3-per-cent-nicotine–lime dust, 7½ pounds, or 3 quarts, is required, for a 4 per cent mixture, 10 pounds, or 1 gallon. To produce an effective dust, it is necessary to mix the materials so thoroughly that each particle of lime carries a bit of nicotine. This can be easily accomplished by using a self-mixing duster or a ball mixer. Unless the grower is going to use enough of the dust to make it worthwhile to purchase or construct a good mixer, it will be more profitable to buy the dust ready mixed.

A serviceable mixer can be built for home-mixing at a reasonable cost. A 50-gallon cider barrel is used for mixing the dust. An opening 6 by 8 inches is cut out in the side for a door, which is attached with strap hinges and fastened with a button. The edges should be padded to prevent leakage. In the center of each end of the barrel fasten a 1¼- by 1-inch bushing. In each bushing screw a piece of 1-inch pipe 6 inches in length. These will serve as an axle on which to rotate the barrel. The barrel is then mounted, at a convenient height, so that it can be rotated by a crank attached to one end of the axle.

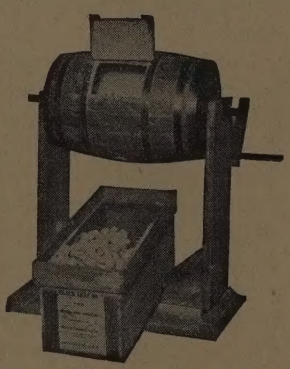

FIGURE 8. MACHINE FOR HOME-MIXING NICOTINE-LIME DUST

To make the dust, put 50 pounds of hydrated lime in the barrel. Then pour the proper amount of nicotine sulfate on top of the lime. For each pound of the dust add about ½pound of hard stones or pebbles, from ¾ inch to 1½ inches in diameter, to aid in the mixing. The barrel should then be rotated rather slowly, thirty-five revolutions per minute, for not less than five minutes. It is better to use a watch and not to guess at the time. When the mixture is finished, the dust should be dumped out into a box provided with a screened lid to remove the stones. The dust should be stored in tight metal drums or, if to be used at once, placed in paper sacks such as are used for lime.

Since the nicotine strength is likely to deteriorate if the dust is stored for a considerable time, a fresh product is desirable.

SOAP

Soaps are used with nicotine sulfate and water to liberate the nicotine and to increase the wetting and spreading qualities of the spray. The most satisfactory soap for this purpose is potash fish-oil soap. This is a soft soap, dissolving easily in water. The harder soda fish-oil soaps and laundry soap are unsatisfactory because of the difficulty of dissolving them. Soaps vary greatly in water content. The amount to use, therefore, varies considerably, usually from 3 to 5 pounds in 100 gallons of the spray mixture.

ROTENONE

(Derris or cube insecticides)

Rotenone is one of the newer insecticides especially useful to control insects on vegetable crops where it is unsafe to apply arsenical poisons. The chief source of rotenone is derris root, a tropical product. The strength of rotenone preparations is indicated by the proportion of rotenone that they contain. This is only an approximation because some of the other ingredients have decided insecticidal value. Insecticides containing rotenone as the principal active ingredient are available in two forms, extracts and dusts.

Derris or cube extracts that contain known amounts of rotenone are sold under various trade names. These preparations may also contain pyrethrins in varying amounts, equal to, or slightly in excess of the rotenone content. Because of their high cost at effective dilutions, their use is chiefly confined to garden plantings.

Rotenone dusts are prepared from powdered derris root and contain, in addition to rotenone, other organic poisons toxic to many insects. Talc or clay seem to be the cheapest and most satisfactory diluents. These dusts can be purchased ready mixed. Several dealers and growers' organizations are buying ground derris root and the diluent, and mixing them for local use. Individual growers with large acreage are also preparing the dust, mixing it in a mixer similar to the one described on page 85 for nicotine dust.

PYRETHRUM

Pyrethrum is an insecticide prepared from the flowers of a plant of the same name. The insecticidal value of these preparations is dependent on the presence of two organic poisons known as *pyrethrins*. Pyrethrum insecticides are sold in two forms, extracts and dusts.

In the extracts the pyrethrins are combined in various ways with such solvents and spreaders as alcohols and soaps. Most of these extracts are too expensive, when used at effective dilutions, for use on large commercial plantings. They are, however, useful in the home garden.

Pyrethrum dusts are largely composed of ground pyrethrum flowers diluted with talc, clay, gypsum, tobacco powder, or finely ground sulfur. To be effective, such dusts should contain not less than ½ of 1 per cent of pyrethrins. These dusts are more economical than liquid pyrethrum preparations.

MAGNESIUM ARSENATE

The commercial use of magnesium arsenate is restricted almost entirely to the control of the Mexican bean beetle. It is preferred for this purpose because it is less likely to injure bean foliage than is calcium arsenate.

LEAD ARSENATE

The use of lead arsenate is not advisable on most vegetable crops because there is danger that harmful residues may be left on the plants.

CALCIUM ARSENATE

The use of calcium arsenate on vegetable crops is restricted almost entirely to the control of the Mexican bean beetle. Even for this purpose it is not so satisfactory as magnesium arsenate. It is sold in the form of a white, light fluffy powder.

FLUOSILICATES

A number of insecticides in which the poisonous principle is some compound of fluorine are on the market. These preparations should not be used on vegetables where there is any possibility that any of the residue will be found on the crop sent to market.

Cornell's Reputation

IN the field of natural sciences, Cornell's reputation has been largely enhanced by the achievement of its entomologists.

Dr. L. O. Howard, for many years head of the Bureau of Entomology of the United States Department of Agriculture, was trained at Cornell University, as were John Henry Comstock and Anna Botsford Comstock, who did so much to popularize the study of insects, and to make that study directly applicable to man's contact with the insect world.

Cornell is still contributing to the knowledge of insects; and some recent publications are here listed:

The control of aphids on house plants (E 162) *Griswold*

Honeybees for the orchard (E 190) *Phillips*

Common insects of the household (E 202) *Herrick* and *Griswold*

The fumigation of greenhouses to destroy insect pests (P 474) *Herrick* and *Griswold*

Some shade-tree pests and their control (P 515) *Herrick*

Ask for these from the

Office of Publication
New York State College of Agriculture
Ithaca, New York

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